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FROM LA NATURE.

WE give this week several illustrations from our contemporary, *La Nature*, namely: A Flint containing Water; Cork Cloth; Bung for preserving Wines, etc.; Safety Catch; A New Lamp Shade; Apparatus for examining Engravings.

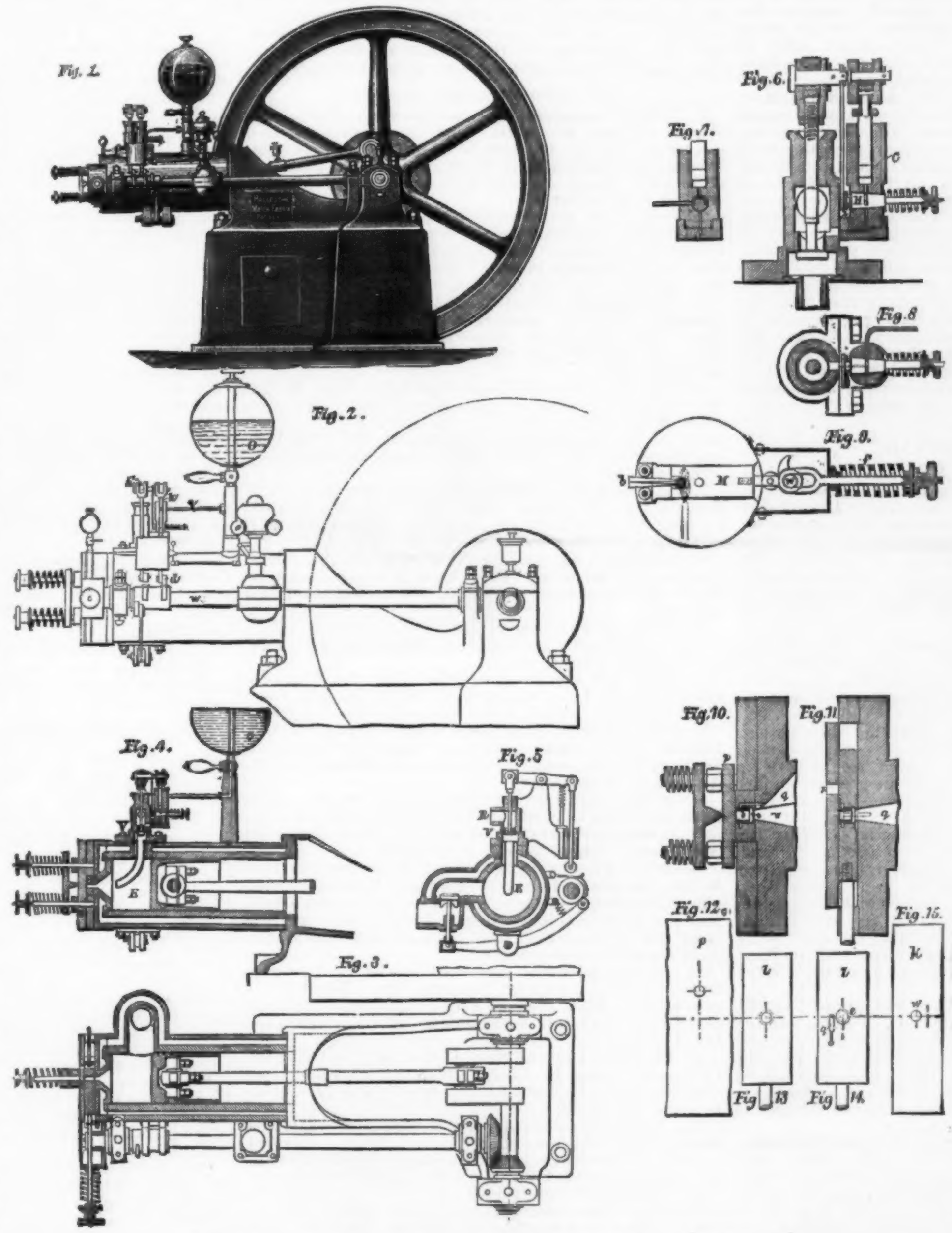
SPIEL'S PETROLEUM ENGINE.

A VERY neat and successful form of petroleum engine, invented by Mr. Johannes Spiel, of Berlin, has, says *Engineering*, lately been introduced in London. The cycle of operations is that with which the reports of the gas engine law cases have familiarized all the world; the piston on its outstroke draws in a charge of air and petroleum; it then returns, compressing this mixture, which is exploded as the crank passes the back center. The next stroke sees the combustion and expansion of the charge, while the fourth and last stroke of the cycle drives out the products of combustion. There is thus one acting stroke in every four, the motion being continued through the other three by the energy stored in the flywheel.

The source of power is petroleum spirit, otherwise known as benzoline, and also as naphtha. This has a specific gravity of 0·7 or 0·71, and a very low flashing point, so that it will not pass the Abel test; consequently it cannot be stored and used without special precautions. If the proper conditions are observed, the use of this spirit does not involve any extraordinary risk, for it is employed in large quantities in the dry cleaning process, and also in the manufacture of India rubber. When used with this engine, it is stored in a closed receptacle connected by a pipe and hand pump to the reservoir, O, Fig. 2. From this reservoir there runs a pipe to the pump, *k* (Figs. 2, 3, and 6), by which measured quantities are injected into the cylinder. At the bottom of the pump there is, in place of a foot valve, a plug, *a* (Figs. 6, 7, and 8), worked by a link from a tappet, as will be presently explained. During the induction stroke of the piston, the cock is turned into a position which permits the liquid in the pump to gain access through the passage, *z*, to the space above the inlet valve, N, while at the same time the admission of liquid through the pipe, *n*, from the reservoir, O, is cut off. During the remaining strokes of the cycle the cock occupies such a position as to cut off the communication with the valve, V, while the pump is again placed in communication with the reservoir, O. The petroleum does not pass through the plug, but along a channel cut round it. The passage of the oil or spirit from the pump, *k*, to the cylinder is past the valve, V, and through the pipe, E. The air enters by the branch, R, and in passing the valve, V, it drives forward the spirit, breaking it into fine globules, and carrying it into the cylinder in admixture with itself. The curved gutter, *t* (Fig. 6), formed round the mouth of the pipe, E, serves to arrest any liquid that may be imperfectly mixed, and as the explosive mixture flows over it, and beneath the valve, the gutter tends to direct the current upward so as to break up and still further mix the air with the liquid. The valve, the pump, and plug, *a*, are operated by a cam on the shaft, *w*, which is driven by bevel gear, and revolves at half the speed of the crankshaft. A crosshead, *h* and h^1, is connected to a rocking beam, which at its other extremity carries a rod ending in a roller, which runs in contact with the cam, and is raised at the appropriate times. A spring draws down the roller when the projection on the cam has passed. Another portion of the cam opens the exhaust valve (Fig. 5). The firing valve (Fig. 9) consists of a plate, M, operated by a lappet on the end of a shaft, *w*. The valve spindle is prolonged and provided with a spring by which the valve is shot back when the tappet ceases to act on the friction bowl. The force of the recoil is moderated by the spring stops, *b*, which run between the rollers, *g g*, and must be compressed as the valve nears the end of its stroke.

The firing light is the flame of a lamp which is kept constantly burning. At a suitable moment it ignites the burner in the valve, and by the quick return movement a flash is transported to the firing apparatus in the cylinder. The combustible mixture finds its way into the burner during the compression stroke. In front, and surrounding the burner, is a chamber, *e* (Figs. 10 to 12), which serves to convey a flame from the outer jet, *i*, to the charge in the cylinder. The chamber, *e*, forms an annular space round the burner, and the passage, *q*, opens into this space, and maintains a communication for the supply of the combustible gas or vapor during the times when the main passage, *w*, is closed. The gas passing through *q* flows round the burner, and thus becomes heated and ignites more readily.

When the chamber is filled with gas, the valve, *l*, is moved by the ram, *d*, until the burner, *b*, is opposite the port, *z*, in the cover, *p*. The gas is then ignited by the outer flame, and continues to burn during the return stroke of the firing valve until the chamber, *e*, comes opposite the passage, *w*, when the charge in the combustion chamber of the cylinder is ignited. The maintenance of the firing flame is effected by the flow of gas through the passage, *q*. The engine at present in this country will work up to 3½ brake horse power, with a consumption of about one quart of benzoline per horse power per hour; the same rate of consumption is also obtained if the power be reduced to two horse power. At the rate of 8d. per gallon, this represents an expenditure of 2d. per brake horse power per hour. The motor works very satisfactorily, does not clog in the valves or cylinders, and bids fair to find a good field where gas is unattainable and the local rules concerning the storage and transport for petroleum spirit are not too stringent.



SPIEL'S IMPROVED PETROLEUM ENGINE.

TORPEDO BOATS.

AMONG theorists there is—and will be, until there is a war—considerable difference of opinion concerning the part which torpedo boats can be made to play in naval warfare. But there is no difference of opinion concerning the mechanical perfection which has been attained in their construction. Only those who have had to design such craft—and their number is extremely limited—can form any conception of the complexity and difficulty of the problem presented for solution. So much has to be done and the space and weight available are so small that the torpedo boat may really be regarded as one of the highest triumphs of engineering skill ever produced. In the first place, a hull has to be produced which, while not much thicker than the pasteboard cover of a book, must be competent to withstand, without in any way losing its form, violent strains, not only from the sea without, but from the machinery within. In this light craft we have concentrated in one place a boiler weighing several tons, in another a quantity of coal, and further aft engines capable of exerting from 500 to 1,000 indicated horse power. It seems absurd to suppose that a boiler can be carried in so flimsy a structure without going through the bottom of it, or that it can be possible to fasten down machinery to so light a hull. The hull is, however, much stronger than it looks. To *thin* steel plates no exception need be taken. These, at all events, are honest, and do not play pranks with the reputation of the metal; and they are so skillfully and carefully put together and stiffened here, there, and everywhere by ribs and angle-bars, that a torpedo boat is, for its weight, probably one of the strongest structures made. Leaving the hull, we come to the boiler. The points of difference between this boiler and that of a locomotive are numerous and important. The power developed, weight for weight, is much greater. A first-class torpedo boat boiler has a heating surface of about 650 square feet, 18 or 19 square feet of grate, over 200 tubes, 6 ft. long and 1½ in. diameter inside. The working pressure is about 120 lb. The tube surface is not more than half that allowed in a locomotive boiler of the same power. The grate area is about the same. Experiments made at Portsmouth have shown a consumption of fuel at the rate of 96 lb. per square foot of grate per hour with 6 in. of water air pressure; but this rate has been considerably exceeded. As much as 10,840 lb. of water were evaporated per hour, or at the rate of 6 lb. of water per pound of coal, omitting fractions. This is a wonderful economic performance, considering the conditions; but it is nothing compared with the absolute efficiency. Taking the total heating surface at 650 square feet, we have an evaporation at the enormous rate of 17 lb. per square foot of surface per hour. If we suppose that the tubes did one-half the work and the fire-box the other half, we find that as

the fire-box surface was about 60 square feet, about 93 lb. of water were evaporated by each square foot, while each square foot of tube surface evaporated about 9·3 lb. No other steam generator in the world has such an efficiency as this. It is not remarkable that special skill and ingenuity has had to be displayed in order to get a boiler to stand such a strain and to supply fairly dry steam without priming, and this, be it remembered, in a boat tossed on a rough sea. The engines are miracles of lightness and perfection of material and workmanship. Nothing but the best workmanship, in the fullest sense of the term, can be made to answer. The very screw propeller used has been evolved by Mr. Yarrow from almost countless experiments, particulars of some of which of the most interesting character have already been published in the *Engineer*. We shall say nothing of the armament of these craft; that is a subject which for the moment we do not discuss.

Perfect as the torpedo boat has been and is, it does not seem that finality has been reached. Messrs. Yarrow & Co. appear to be able to meet every demand made on them for faster and faster boats. To Mr. Thornycroft, of Chiswick, belongs the distinction of being the first man who ever drove any craft at the rate of 19 knots, or 22 miles, an hour through the water. Mr. Yarrow, however, was the first to run a boat at 22 knots, or 25·36 miles; and even this performance he has recently beaten, for he is now building boats capable of running at 24 knots, or 27·66 miles, an hour. It is a noteworthy circumstance, however, that our own government is perfectly contented with 19 knots, although no other government is. It is admitted on all sides that high speed is essential to the success of torpedo boats; yet, in the face of this, England is acquiring a fleet of the slowest torpedo boats in the world, and this while every endeavor is being made to accelerate the speed of every other class of fighting ship. We have no doubt that the facts have been overlooked by the Admiralty, for which there has been every excuse. As soon as administrative matters have settled down a little into shape, torpedo boats will again receive the attention they deserve, and orders will be given that the highest possible speeds shall be attained. If foreign governments attach importance to having boats which can steam 22 knots an hour, that importance is either well founded or it is not, and steps should be taken, if necessary, to ascertain the reasons on which the preference for high speeds is based. It may be shown that there are some counteracting disadvantages—though we much doubt this—which have weighed with our own Admiralty. If so, they should be explained, in order that they may be removed. Our own conviction is that speed ought to be had at any price, and we have little doubt that the moment attention is drawn, as we have drawn it, to the subject, precautions will be taken to give Great Britain boats as speedy as anything that European or American governments can show.—*The Engineer.*

THE FIRE-GRENADE.

PROF. F. S. KEDZIE, of the Michigan State Agricultural College, after a series of analyses and experiments, draws some important conclusions as to the value of hand-grenades, in a paper which he publishes in the Chicago *Sanitary News* of November 7.

A Harden hand-grenade was opened, and the solution contained qualitatively analyzed. It consisted of common salt, sulphate of lime, and a small amount of acetate of soda. The principal ingredient was common salt.

The effort was made to determine (1) whether the solution in the grenades had any more extinguishing power than water; (2) if the solution had extinguishing power greater than water, what was the essential ingredient in the solution.

The question that first arose regarding the composition of the grenades was: Did they contain carbon dioxide gas, or any substance which would give up the gas by being heated? Opening the grenades under water and collecting the gas that escaped, it was found that the average amount of carbon dioxide contained was about one cubic inch per grenade. Boiling the solution liberated a slight amount of gas in addition; but altogether the gas was not enough to be of any practical benefit in extinguishing fire. It was then certain that the extinguishing power was in the solution itself. Replacing the solution in the grenade with pure water, the extinguishing power, while greater than water thrown from a dish upon the flaming boards, was still much less than the power exerted by the solution.

By a careful series of trials, it was found that the essential ingredient was common salt. From a number of experiments it was found that when a grenade, or a bottle containing a strong brine, was broken in the midst of the burning kerosene, the flames were almost instantly extinguished. A vapor seemed to spread in all directions from where the salt solution struck the board, extinguishing the flame as it went.

Strong solutions were also made of sulphate of soda, hyposulphite of soda, borax (biborate of soda), and bicarbonate of soda, and tried as extinguishers. Some worked as well, but none any better than salt in extinguishing fire.

The experiment was then tried of charging the bottles with brine, and generating carbon dioxide by adding lime dust and sulphuric acid and corking tightly. No practical increase in extinguishing power from this addition was noticed. In most instances, the carbon dioxide gas escaped from the bottle inside of four days, proving that it is impracticable to attempt to use glass vessels with corks as a means of storing CO_2 under pressure for fire extinguishing purposes.

The conclusion arrived at from these and many more experiments was that the Harden grenade solution possesses much greater extinguishing power than water alone, and that it owed this power to common salt held in solution.

"We then constructed some home made grenades, using flat bottles, bound together side by side with wire. Using two bottles in this way insures their being broken on striking the burning body, which would not always occur when only one bottle is used. Bottles thus charged with brine and bound together were broken side by side with the Harden grenades and found to be equally valuable.

"It thus appears from the experiment that any person can construct as good and effective grenades as those offered in the market at seven dollars and ten dollars per dozen. Bottles filled with brine, and placed around the premises, will afford considerable protection, especially if used upon the flames when the fire just begins. Salt solutions have the further advantage of not being easily frozen, never enough to burst the containing bottle.

"The Lewis hand fire extinguisher was next investigated. This consists of a tin tube about two feet long, containing thirty-four fluid ounces of a solution consisting of a sulphite of soda in weak caustic ammonia. From the trials made we could not notice any appreciable superiority over the salt solution, as used in the Harden grenade. It has the disadvantage of not being made to break by being thrown, but must be opened by having a cork extracted from one end of the tin tube, requiring a smart jerk. The solution is then sprinkled on the fire by the operator.

"The principal value of this form of extinguisher must consist in the advice to the consumer printed upon the outside of the instrument, to 'Keep cool—not get excited,' etc., which, seeing that he holds the tin case in his hand while distributing the contents on the flames, allows him to consult and follow minutely this most excellent advice."

THE BESSEMER STEEL INDUSTRY OF THE UNITED STATES.

FOR the purpose of showing the magnitude of this industry, the *Bulletin of the American Iron and Steel Association* has prepared the accompanying list of all the companies and firms that have been engaged in the manufacture of Bessemer steel in the United States, or are now erecting Bessemer steel works. Several companies that have gone out of existence are included in this list, in order to present a complete historical statement of the growth of the industry. The names of these companies are printed in italics.

STANDARD BESSEMER PLANTS.

1. *Kelly Pneumatic Process Company, Wyandotte, Wayne County, Michigan.* One 2½ ton experimental converter. Made its first blow in the fall of 1864. Bought by Captain E. B. Ward in 1865, and abandoned in 1869. These experimental works were connected with an iron rolling mill.

2. Troy Steel and Iron Company, Troy, New York. Experimental Bessemer plant established by Winslow, Griswold & Holley. One 2½ ton converter. Made its first blow February 15, 1865. Now two 10 ton converters. Added to an iron rail mill.

3. Pennsylvania Steel Works, Pennsylvania Steel Company, Steelton post-office, Dauphin County, Pa. Two 7 ton converters. Made their first blow in June, 1867. An entirely new works. Three 8 ton converters added in 1881.

4. *Freedom Iron and Steel Works, Lewiston, Mifflin County, Pa.* Two 5 ton converters. Made their first blow May 1, 1868. Added to the forge and blast-furnaces of the Freedom Iron Company. Failed in 1869, and Bessemer works dismantled; most of the machinery went to Joliet, Illinois.

5. Cleveland Rolling Mill Company, Cleveland, Ohio. Two 6¼ ton converters. Made their first blow October 15, 1868. Now two 10 ton converters. Added to an iron rail mill.

6. Cambria Iron and Steel Works, Cambria Iron Company, Johnstown, Pa. Two 6 ton converters. Made their first blow July 10, 1871. Added to an iron rail mill.

7. Union Steel Company, Chicago, Illinois. Two 6 ton converters. Made its first blow July 26, 1871. Added to an iron rail mill.

8. North Chicago Rolling Mill Company, Chicago, Illinois. Two 6 ton converters. Made its first blow April 10, 1872. Added to an iron rail mill. *See No.* 17.

9. Joliet Steel Works, Joliet Steel Company, Joliet, Illinois. Two 8 ton converters. Made its first blow January 26, 1873, and its first steel rail March 15, 1873. An entirely new works.

10. Bethlehem Iron Company, Bethlehem, Pa. Two 7 ton converters. Made its first blow October 4, 1873, and its first steel rail October 18, 1873. Now four 7 ton converters. Added to an iron rail mill.

11. Edgar Thomson Steel Works, Carnegie Brothers & Co., Limited, Bessemer Station, Braddock post-office, Allegheny County, Pa. Two 7 ton converters. Made their first blow August 25, 1875, and their first steel rail September 1, 1875. An entirely new works. Now three 10 ton converters.

12. Lackawanna Iron and Steel Works, Lackawanna Iron and Coal Company, Scranton, Pa. Two 6$\frac{6}{10}$ ton converters. Made their first blow October 23, 1875, and their first steel rail December 29, 1875. Added to an iron rail mill.

13. St. Louis Ore and Steel Company, Western Steel Company, lessees, St. Louis, Missouri. Two 7 ton converters. Made its first blow September 1, 1876. Added to an iron rail mill.

14. Pittsburg Bessemer Steel Company, Limited, Homestead, Allegheny County, Pa. Two 4 ton converters. Made its first blow March 19, 1881, and its first steel rail August 9, 1881. An entirely new works.

15. Pittsburg Steel Casting Company, Pittsburg, Pa. One 5 ton converter. Made its first blow August 26, 1881. Added to a crucible steel works. Product, ingots for special purposes and steel castings; works not intended for the production of rails.

16. Colorado Coal and Iron Company, South Pueblo, Colorado. Two 5 ton converters. Made its first blow April 11, 1882. An entirely new works.

17. North Chicago Rolling Mill Company, South Chicago, Illinois. Three 10 ton converters. Made its first blow June 14, 1882. An entirely new works. *See No.* 8.

18. Scranton Steel Company, Scranton, Pa. Two 4 ton converters. Made its first blow March 29, 1883, and its first steel rail May 4, 1883. An entirely new works.

19. Bellaire Nail Works, Bellaire, Belmont County, Ohio. Two 4 ton converters. Made their first blow April 28, 1884. Added to an iron rolling mill. Product, ingots to be rolled into steel nail plate.

20. Worcester Steel Works, Worcester, Mass. Two 4 ton converters. Made their first blow June 2, 1884. Added to an iron rolling mill.

21. Riverside Iron Works, Wheeling, West Virginia. Two 5 ton converters. Made their first blow June 11, 1884. Added to an iron rolling mill. Product, ingots to be rolled into steel nail plate.

22. Otis Iron and Steel Company, Cleveland, Ohio. One 5 ton converter. Made its first blow August 5, 1884. Added to an open hearth steel works. Product, steel for rolling directly into wire rods.

23. American Iron and Steel Works, Jones & Laughlins, Limited, Pittsburg, Pa. Building a Bessemer steel plant as an addition to their iron rolling mill, to contain two 7 ton converters. Expect to be in operation early in 1886. Product, ingots for all purposes.

24. Juniata Iron and Steel Works, Shoenberger & Co., Pittsburg, Pa. Building one 7 ton Bessemer converter as an addition to their iron rolling mill and open hearth steel works. To be completed early in 1886, and its product to be used for nail plate, shapes, plates, sheets, and bars.

25. Wheeling Steel Works, Wheeling, West Virginia. Building two 5 ton Bessemer converters. An entirely new plant. Expect to be in operation by March 1, 1886. Product, ingots for rolling into nail plate.

26. Laughlin & Junction Steel Company, Mingo Junction, Jefferson County, Ohio. Two 5 ton Bessemer converters. Made its first blow February 3, 1886. An entirely new plant. Product, ingots for rolling into nail plate, etc.

CLAPP-GRIFFITHS PLANTS.

27. Oliver Brothers & Phillips, Pittsburg, Pa. One 2 ton Clapp-Griffiths stationary converter. Made their first blow March 25, 1884. Now, two 2 ton converters. Added to an iron rolling mill. Product, ingots for special purposes, not including rails.

28. Birdsboro' Nail Works, E. & G. Brooke Iron Company, Birdsboro', Berks County, Pa. One 1½ ton tilting converter. Made its first blow September 22, 1885. A new steel plant in course of erection, described by Mr. James P. Witherow as follows: "This plant will consist of two 3 ton converters, only one of which will be completed at present. It is now intended to be of the tipping type, having the Clapp-Griffiths movable bottom and slag-tapping holes. It can be worked either as a tipping or stationary converter, with all of the Clapp-Griffiths distinctive features and equipments." Added to an iron rolling mill. Product, ingots for rolling into nail plate.

29. Port Henry Steel and Iron Company, Limited, Port Henry, New York. Building a Clapp-Griffiths plant, to contain two 3 ton converters. Expects to be in operation early in 1886. Added to a blast-furnace plant. Product, ingots for special purposes.

30. Glasgow Iron Company, Pottstown, Pa. Building two 3 ton Clapp-Griffiths converters. Expects to be in operation early in the spring of 1886. Added to an iron rolling mill. Product, ingots for boiler and other plates, including nail plate and sheets.

31. Pottsville Iron and Steel Company, Pottsville, Pa. Building a Clapp-Griffiths steel plant, as an addition to its iron rolling mill, to contain two 3 ton converters. Expects to be in operation early in 1886. Product, ingots for structural steel.

32. McCormick & Co., Harrisburg, Pa. Building a Clapp-Griffiths steel plant, as an auxiliary to their iron rolling mills, to contain one converter. Expect to be in operation early in 1886.

33. Lickdale Iron company, Lebanon, Pa. Building an entirely new plant, to contain Clapp-Griffiths steel converters, and to make plates.

34. Western Nail Company, Belleville, St. Clair County, Illinois. Two 3 ton Clapp-Griffiths converters. Made its first blow January 21, 1886. Added to an iron rolling mill. Product, ingots for rolling into nail plate.

MISCELLANEOUS.

35. Trenton Iron Company, Trenton, New Jersey. One 2 ton Gordon converter, completed in January, 1886. Added to an iron rolling mill. Product, ingots for wire rods and special purposes.

36. Pottstown Iron Company, Pottstown, Pa. Building a steel plant as an addition to its iron rolling mill. Particulars not yet made public. Will make steel plates and nail plate.

COMMENTS.

Bessemer steel by the original, or acid, process can now be manufactured in the United States, and has for several years been manufactured, without payment of royalty for the use of any patent whatever, all the essential patents having expired.

With reference to the Clapp-Griffiths plants now under construction, Mr. Witherow writes that all are to be supported by two 3 ton converters, provision being made for an additional converter where one is building. The 2 ton converters of Oliver Brothers & Phillips, he says, now average from 160 to 175 tons in twenty-four hours, and could work to over 200 tons, but they have to work under the disadvantage of having no blooming mill for their ingots.

There is not one basic Bessemer plant in the country, if we except the old Bessemer plant of the Pennsylvania Steel Company, which was operated experimentally for a short time on basic steel, with unsatisfactory economic results.

The Bessemer steel industry, it will be observed from the above list, is no longer confined to a few establishments located in three or four States. Twenty-four Bessemer steel works now exist in no less than nine States, namely, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, West Virginia, Illinois, Missouri, and Colorado, while ten more works scattered over some of the States named are in course of erection, and fast nearing completion, with others still projected. Omitting the Pottstown Iron Company's plant, of which we have as yet no definite information, the completed and partly finished works contain converters as follows: Completed works—ten 10 ton, five 8 ton, ten 7 ton, six 6 ton, eight 5 ton, eight 4 ton, two 3 ton, three 2 ton, and one 1½ ton; partly finished works—three 7 ton, two 5 ton, and nine 3 ton. Total, 67 converters, of which 53 are completed and 14 partly finished.

A STEEL color on brass is developed by using a boiling solution of arsenic chloride, while a careful application of a concentrated solution of sodium sulphide causes a blue coloration. Black being generally used for optical instruments, is obtained from a solution of platinum chloride, to which tin nitrate has been added. In Japan the brass is bronzed by using a boiling solution of copper sulphate, alum, and verdigris.—*Manufacturer and Builder.*

PERILLE'S SAFETY CATCH.

THE apparatus herewith illustrated is designed to act as a substitute for the ordinary door bolt and safety chain. It permits of entirely closing a door, or of opening it on a crack to see who the visitor is, receive a letter, etc., from him, without allowing him to enter in case his presence is not desirable.

In Fig. 1 the apparatus is shown unfastened, and the door can be freely opened. In Fig. 2 the catch is placed at right angles with the plane of the door, and, forming a strong bolt, the door cannot be opened. In Fig. 3 it is turned sidewise so as to form a safety chain. In this case the door can be partially opened, but only the length of the catch, as shown in Fig. 4. It is impossible to force a passage, but there is room enough to admit the hand.

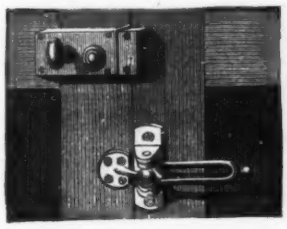


FIG. 1.—The Catch Open.

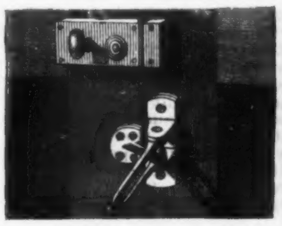
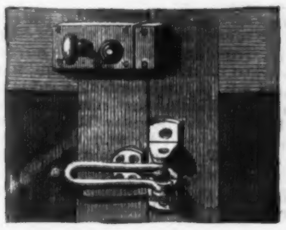
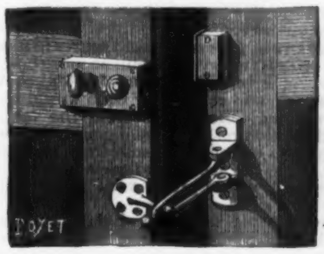


FIG. 2.—The Same Forming a Bolt.





FIGS. 3 AND 4.—The Same as a Safety Chain.

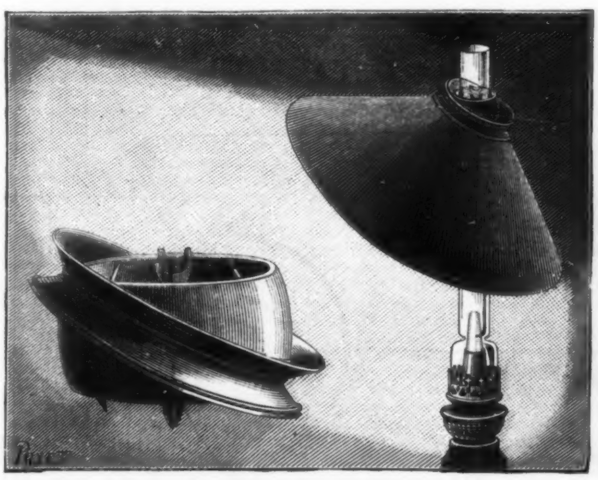
PERILLE'S SAFETY CATCH.

Our engravings allow the mechanism to be well enough understood without the necessity of a long description. The door is provided with a steel rod terminating in a knob which slides between the arms of the catch fixed to the jambs. In the closed position (Fig. 2) the knob is held by the arms of the catch, which are too close together to give it passage. The catch must be pushed to one side in order that the fixed rod shall slide in it—the knob then being outside, as shown in Fig. 4.

This catch is of nickelized steel, and is very neat in appearance. It will be found very useful for front doors. The two parts of the apparatus are fixed to the wood of the door and jambs by large screws, and it would be impossible for thieves to force it off with nippers, as they do ordinary locks.

A NEW LAMP SHADE.

WHEN a lamp is provided with an ordinary shade, it is necessary to remove the latter whenever it is desired to illuminate any other spot in a room other than the surface of the table upon which the lamp stands. Mr. Bara, an engineer, has recently devised a very practical system that permits of inclining the shade in any direction whatever, as shown in the accompanying figure. This spherically rotating shade is very convenient, and we recommend it to our readers.

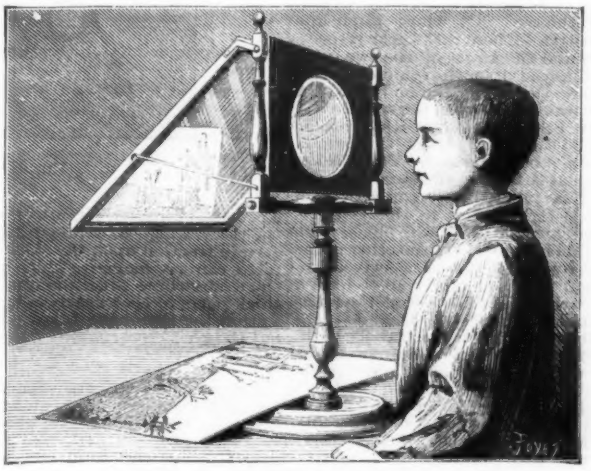


A NEW LAMP SHADE.

The apparatus, which is interesting in itself, is likewise curious by reason of the peculiar mode of manufacture that it necessitates. The piece with a spherical surface that supports the shade presented difficulties in the way of construction that have been overcome by Mr. Lieux, the manufacturer, in the following way: A thin metallic cylinder is placed in a steel mould of the desired spherical form. A rubber plug is introduced into the cylinder, so as to fill it. This done, the elastic plug is strongly compressed by means of a stamping press analogous to those that are used for coining money. The pressure upon the metallic cylinder causes it to take the spherical form of the steel mould. The other parts of the shade are made by the ordinary processes. Our figure so well shows the arrangement and mounting that it is unnecessary to dwell longer upon this useful improvement of a small household article.

APPARATUS FOR EXAMINING ENGRAVINGS.

AMATEURS of prints know that there exists a large number of engravings whose title is printed in reversed letters that cannot be read directly, but only by being reflected from a mirror. One of our readers has asked for an explanation of this fact, and the subject has seemed to us of sufficient general interest to be treated of in this place. These (usually colored) engravings with reversed letters constitute what our fathers called "optical views." They were examined by means of an apparatus that was in reality a sort of monostereoscope with a large lens. We reproduce the apparatus herewith from an old model. The engraving was laid flat upon the table with the top turned toward the observer, who, looking through a large concavo-concave lens, saw an enlarged and right-side up image of the engraving, owing to a mirror inclined 45°, as shown in the figure. The engraving appears vertical in the apparatus, its title becomes readable, and the subjects represented have a remarkable semblance of relief. This old apparatus can be very easily constructed, and is very useful for examining engravings, drawings, and aquarelles.



APPARATUS FOR EXAMINING ENGRAVINGS.

DAKOTA farmers are making plans to grow flax for fuel this summer. It is said that a ton of flax straw is worth more to burn than a ton of soft coal.

CORK CLOTH.

MR. WILLIAM JACKSON, director of the Bureau of Equipments for the Army and Navy, in Victoria Street, London, is the inventor of a cloth of which the weft is of cork fiber cut from the bark by a special tool. The warp is of wool, silk, linen, or hemp, according to circumstances. As the cork fiber easily retains the dye employed for the textile with which it is associated, there is nothing in the appearance of this new fabric to distinguish it from the cloth employed for the overcoats of navy officers, sailors, and passengers. Clothes made from it are as convenient, and supple, and almost as light as ordinary garments; and, moreover, they possess the valuable property of sustaining their wearers without the latter having need to make the least motion on the surface of the water. The material may be used for making bathing suits, which are as flexible as the cotton ones furnished at the seaside, which adapt themselves to all the motions of swimming, and by means of which a person may venture as far as he chooses. Numerous experiments were performed last August on the Isle of Wight and in the Thames under the eyes of the Lord Mayor; and cork garments have likewise been tried in swimming baths at London and Ryde, and in the great piscina of Rochechouart Street. In the Isle of Wight experiments, six persons (three of them ladies who did not know how to swim) jumped into the sea together, and floated for more than an hour in the presence of an immense crowd, which warmly applauded these new sirens and tritons.

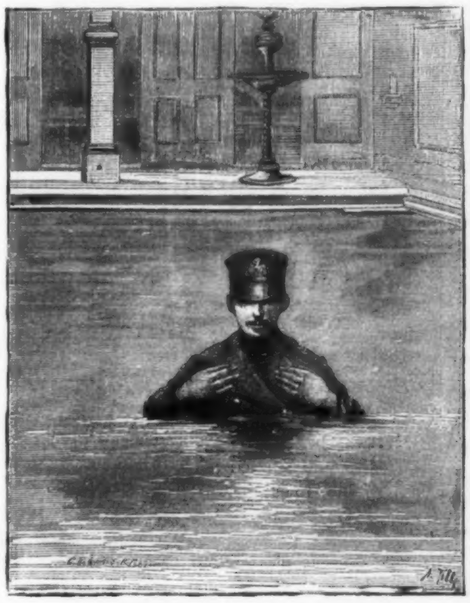


FIG. 1.—ENGLISH SOLDIER CLOTHED IN CORK CLOTH.

The facility with which the properties of cork cloth have been utilized to produce this happy result will be readily understood when we state that a piece measuring $3\frac{1}{2} \times 2\frac{1}{4}$ inches has supported a weight of 180 grains after being first saturated with water. These figures show that a piece having a superficies of one yard would sustain about four and a quarter pounds. It may be admitted that it requires but slight effort to support a lean man above the surface of the water, and as the density of cork is about a quarter that of water, it requires but a weight of about seventeen ounces to effect the result. As cork fiber here takes the place of a textile weft, it will be seen that these seventeen ounces are themselves far from representing the excess of weight over that of a cloth garment employed in the

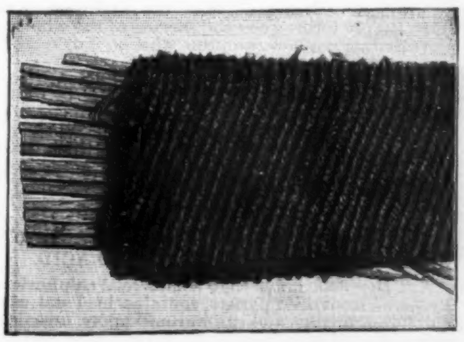


FIG. 2.—TEXTURE OF CORK CLOTH.

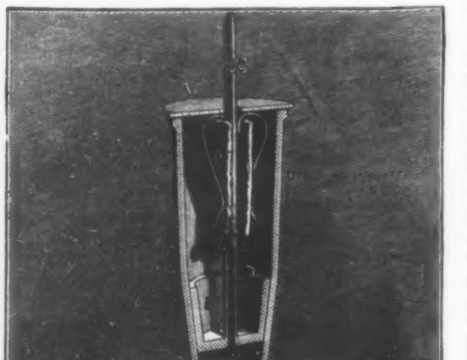
sea, but not possessing the property of sustaining for a single moment the individual whom it invests.

After the above-mentioned experiments, the British Insurance Company decided that the navy officers should have vests of cork cloth in their equipment. It is to be expected that the use of the same will be adopted by pilots and by the crews of life-boats, who have a readily understood repugnance to the cork life-preservers that are furnished them.

BUNG FOR PRESERVING WINES ON TAP.

WHEN a package of wine remains on tap for several days, a portion of the contents acidifies, and the wine, which is at first sweet, gets sourer and sourer in measure as it is drawn off. If, every time one or more bottles of wine were drawn, a bit of sulphured wick could be burned in the cask, the remaining wine would be prevented from souring. But, aside from the fact that such a method would not be convenient, since it would require the bung to be removed each time, it would be impracticable, since the acetic and carbonic acid gases that are developed would prevent the combustion of the wick.

The bung represented herewith obviates such an inconvenience through a utilization of the vacuum produced by drawing the wine for forcing a mixture of air and sulphurous acid gas to enter the cask and form therein an anti-acescent atmosphere. This bung, called "sulphureting," because it produces and utilizes sulphurous acid, is the invention of Mr. Fages, an architect at Narbonne, who has adopted the present form after a year of experimentation, which has in all cases demonstrated the efficacy of the process. The apparatus is made of an alloy, and is easily fitted to any sized cask whatever. When it is desired to use it, it is driven into the bung-hole so as to fix it therein. The cover, A, and cup, B, are removed by means of the rod, C, and the two sulphured wicks, D, held by two springs, are lighted. Then the cup is put back into the apparatus, the cock is opened, and the cover put in place. When the cock is turned off, the sulphur is extinguished for want of air. The wicks are thus capable of serving a great number of times. They should not be over one inch



FAGES' SULPHURETING BUNG.

wide. In order to renew them, it is only necessary to open the springs, D. The excess of melted sulphur drops into the cup, B, which, when full, is emptied by heating it slightly.

The operation of this little apparatus is easily understood. Drawing off the liquor creates a vacuum, which the sulphurous acid enters the cask to fill. The introduction of the gas occurs through two apertures, E, in the hollow rod. The air necessary for the combustion enters through an aperture in the cover. It is not necessary to light the wicks every time the cock is opened in order to draw wine, but it may be done merely from time to time, seeing that it takes a very little sulphurous acid to prevent mould and acidity.

There is one fact worthy of remark, and that is that the color of the wine is in no wise altered. This is due to the fact that the sulphurous acid is not mixed with the wine, as happens when the latter is poured into an atmosphere of this gas. With the sulphureting bung there simply forms upon the surface of the wine a preservative atmosphere, and the wine on tap retains all its qualities up to the last drop.

The process may be rendered completer, if judged necessary, by filtering the air according to Pasteur's method. To do this, cotton is stuffed into the bottom of the apparatus under the cup, B. The object of this cotton, which forms a layer two inches thick, is to arrest the passage of such atmospheric germs as may have escaped the action of the sulphurous acid.

PURIFICATION OF SULPHURIC ACID AND PREPARATION OF NITRIC ACID.

ALL chemists know that commercial sulphuric acid, prepared from iron pyrites, contains lead and calcium sulphates, nitrous and sulphurous vapors, arsenic acid, sometimes selenious acid, thallium sulphate, and hydrogen fluoride. For its purification the author dilutes it with its own weight of water, then passes through it in excess a current of washed sulphurous acid, so as to bring the arsenic and nitric acids to a lower stage of oxidation, and to reduce selenious acid if present. A current of hydrogen sulphide is then passed through it twice, with an interval, each time as long as it is absorbed. The vessel is then closed, and allowed to stand for some time at a moderate temperature, so that the lead and arsenic sulphides, selenium, etc., may subside. The sulphuric acid is then rectified in glass retorts, applying the heat so as to reach the upper portion only.—*Prof. Kupferschlaeger.*

INSTRUMENTS FOR DRAWING CURVES.

By Prof. C. W. MACCORD, Sc.D.

II. THE PARABOLA.

THE operation of the apparatus represented in the accompanying engraving will be understood by aid of the small skeleton diagram at the left of the principal figure. Let F be the focus and DD the directrix of the parabola whose vertex is V. The principles of which advantage is taken in the construction of the instrument are these, viz.: 1. The perpendicular distance from any point on the curve to the directrix is equal to its distance from the focus; and, 2, the tangent at any point bisects the angle included between the perpendicular just mentioned and the straight line joining the point with the focus. For instance, PA is equal to PF, and the tangent PB bisects the angle APF. Consequently, drawing FA, that line is perpendicular to PB, which bisects it at B. Again, drawing FE perpendicular to DD, it follows from 1 that the vertex V bisects FE, and therefore VB is perpendicular to FE, or parallel to DD, and is equal to one-half of EA.

Now, let there be a sleeve at A, and another at B, sliding upon a rod passing through them in the direction BA; then, if these sockets be moved vertically, the former twice as rapidly as the latter, the rod will evidently turn about F as a center. And if a rod PB be fixed to the socket B, at right angles to it, this rod will always be tangent to the parabola. At the point of tangency P are shown two sockets pivoted to each other, one sliding upon the rod PB, the other upon a horizontal rod, which rises and falls vertically with the socket A, to which the rod is pivoted; then the pivot of the two sockets at P must necessarily always lie upon the curve.

Now, in the instrument shown in the larger figure, a bearing for the axis of the revolving rod is provided in the frame OO, and in a bridge piece LL, supported upon and secured to projections upon OO, which act as guides to the slotted rack *rr*, whose pitch line passes through the vertex of the parabola. To OO is also secured a guide K for the rack RR, whose pitch line coincides with the directrix. These racks gear respectively with the smaller and the larger of the two gear-wheels, which are both keyed upon the spindle, so that they turn together, while the rod corresponding to FA of the small diagram turns loosely upon the spindle. A horizontal slotted arm SS is secured to RR, at some distance above it, and to the lower side of this arm is pivoted a socket sliding upon the rod. This socket corresponds to the one at A in the skeleton, and the one corresponding to B is pivoted to a projection on the upper side of *rr*. At right angles to this socket is fixed the long slotted arm GG. Two blocks are arranged, the one to slide in the slot SS, the other in the slot GG; and the pivot by which they are swiveled to each other projects, and is drilled and split to form a pencil holder. The pencil is thus always at the intersection of the center lines of the two slots, and is consequently compelled to travel in a true parabolic path.

This, in the form here presented, is not a true drawing instrument, being without adjustment, and capable of describing the parabola only upon this one scale.

It might be made adjustable by dispensing with the racks and wheels, and making the guides for the sliding pieces RR and *rr* movable upon OO; the only functions of these sliding pieces in that case being to support and control the motions of the slotted arm SS and the two sockets.

The relative velocities of RR and *rr* would then be determined solely by the action of the revolving radial arm upon which the sockets slide, so that as a practical working device it is to be doubted whether it would prove reliable. We have accordingly preferred to present as it is, more as an illustration of the solution of a definite problem in mechanical movement than as anything laying claim to consideration on account of utility.

NEW PROCESS OF CASTING IRON CYLINDERS.

A NEW process of casting, designed to prevent those flaws and hollows that are apt to occur in cast iron, and especially in the cylinders of paper machines, has been devised by Messrs. Cordebart & Co. It consists in placing in the mould, at the place where the defects are likely to occur, cast iron rings of a quality as near as possible that of the iron which is to be cast, and of the form shown in Fig. 1, that is to say, having internal and external edges sufficiently thin to allow them to melt in the molten iron. These rings may be attached to the mould and core in any way desired. As

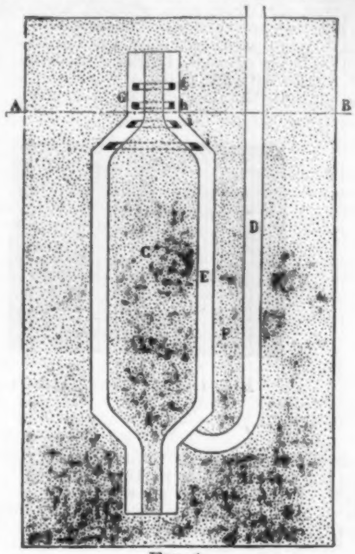


FIG. 1.

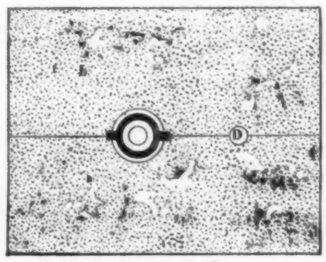
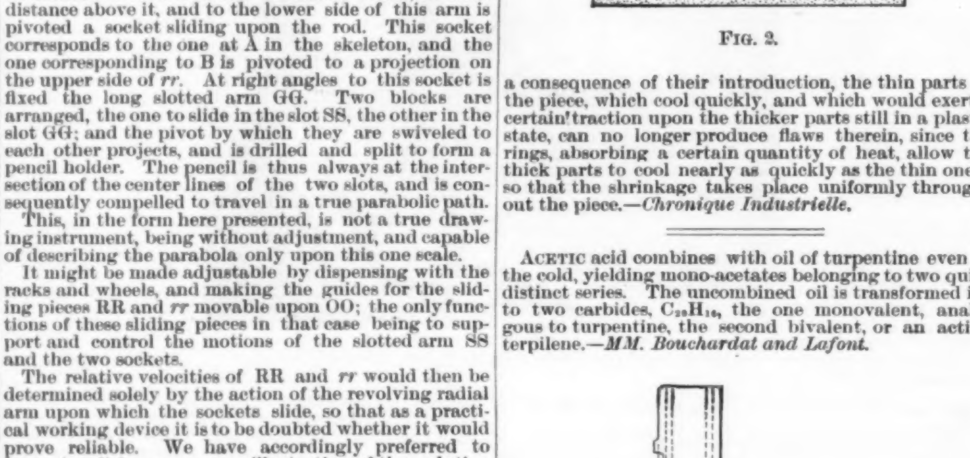


FIG. 2.

a consequence of their introduction, the thin parts of the piece, which cool quickly, and which would exert a certain traction upon the thicker parts still in a plastic state, can no longer produce flaws therein, since the rings, absorbing a certain quantity of heat, allow the thick parts to cool nearly as quickly as the thin ones; so that the shrinkage takes place uniformly throughout the piece.—*Chronique Industrielle.*

ACETIC acid combines with oil of turpentine even in the cold, yielding mono-acetates belonging to two quite distinct series. The uncombined oil is transformed into two carbides, $C_{20}H_{16}$, the one monovalent, analogous to turpentine, the second bivalent, or an active terpilene.—*MM. Bouchardat and Lafont.*



INSTRUMENTS FOR DRAWING CURVES—PARABOLA.

TIMBER: ITS GROWTH, SEASONING, AND PREPARATION FOR USE.*

By THOMAS BLASHILL.

THE first of a course of free lectures on matters connected with building, to be delivered at Carpenters' Hall, London Wall, E. C.

In his opening remarks Mr. Blashill referred to the fact that plants recognized as trees belong to two different classes—the endogenous specimens, in which the fresh matter is added in the center, and the exogenous trees, in which the increase was by coats of wood added on the outside of the stem. In the former class, of which palms were the best recognized illustrations, the center of the tree consists of pith, with an outer husk of bark. In the latter class, to which all our timber trees belonged, we easily recognized three distinct parts—the bark, the wood, and the pith. He would examine the growth of one of the latter class of trees as it appeared say half a century after it sprouted from a seed. The pith, at first a very distinct rod of white, spongy substance, afterward dried and shrunk, becoming partially dead. Outside was the wood in fifty rings, usually very easy to count. All, except a few of the outer rings, were comparatively hard and dry, of darker color than the rest, and practically dead also, because they had ceased to take part in the life of the tree. This was the heart now. Outside, it was one, perhaps three or four—perhaps two—rings of softer wood, full of sap, light in color, and, when carefully examined, considerably alive. Outside this sap-wood was the bark: first the inner bark—white, moist, living, consisting of many thin layers or rays. Finally, there was the outer bark, consisting of a layer containing such coloring matter as the stem might have, and an outer layer resembling the central pith; this might be thin, as in the birch, or thick, as in the cork oak. The lecturer next proceeded to inquire into the manner of growth of a tree with reference to the eventual effect of external and internal influences on the timber. Having alluded to the rise of the sap, the lecturer showed that this fed the thin layer between the inner bark and the last annular ring, so thickening it that, tightly as the bark inclosed the stem, it had to yield to the pressure. The bark consisted of reticulated fibers, which allowed of a certain amount of expansion, but the internal pressure also caused it to crack and peel in places in various ways, according to the thickness of the tree. It should be remembered that the stem was never quite correct, as the rings were never of the same thickness all round. They were generally thickest on the sunny side of the tree. If all the branches and roots were on one side of the tree, as when it stood at the edge of a wood, all the rings were enormously thickened on that side. In the Museum at Kew there was a section of a fir tree which measured from pith to bark on one side 13 in., and on the other side 4 ft., each ring being on an average four times thicker on the one side than on the other. The rings differed from each other also in thickness. As the tree developed fresh branches, the rings tended to get thicker. In a good season they were thickest, in a bad season decidedly thinner, so that a growing tree was a self-acting register of the weather as far as regarded its suitability for vegetation. In fact, we might count the rings back for centuries, and gain some generalization of the average summer weather of each year. When the sapwood was a few years old—say, from three to four years in chestnut, seven years and upward in oak—the sap ceased to flow in it, and it changed in a season to heartwood, but not quite uniformly. Two or three rings would often be turned to heartwood on the sunny side of the tree, while they remained full of sap on the opposite side. The heartwood became solid, and its pores were filled up with any gums or resins that the particular kind of tree produced. The heartwood underwent no further change until the tree grew old, when it was the first part of the wood to decay. The sapwood kept up a sort of growth within itself as long as it existed in that condition.

Another very important feature in the wood of all timber trees was that they produced plates of woody fiber that in the young plant connected the bark with the pith. These were known as "medullary plates." They were not visible to the naked eye, except in oak, beech, and some few other trees. They were very conspicuous in the end grain of oak. As the trunk increased in size fresh medullary plates start up midway between the older ones, and are kept growing at the junction of the sapwood and bark, and extend both toward the center and outer surface. The plates were only a few inches in depth up and down, but between them fresh ones started out, so that they overlapped each other. When we see them in the end grain showing as bright, fine lines, they were termed "medullary rays;" when seen sidewise in a split log, they were known as the "flower," or silver grain. Having exhibited specimens of oak showing these plates, the lecturer referred to the beauty they imparted to this wood, and mentioned that the plates could not be traced in the Spanish chestnut, ash, or elm. The medullary plates were not only ornamental, but very serviceable in oak timber. They added to the strength of the wood across the grain, so that the pins of oak tenons would not draw out. They were harder than the rest of the wood. In an oak slab which had seen many years' rough wear, say the sill in the ticket window of a railway-station on which the booking clerk dashed down his change, the silver graining stood up in ridges above the wood of the annual rings. They resisted shrinkage, decay, and worms, which would only bore through them in order to get at the softer wood beyond. A few things showed how the wood grew by annual layers. Let them suppose that three branches were removed from a tree, one being taken off close to the trunk, the second cut off with a few inches of projection, and the third left long enough to produce twigs and leaves. The new wood would, in a few weeks, grow over the first, leaving a wound in the wood called a bandgall. The second would have become a dead stump, owing to the absence of leaves, and would next be inclosed by the new wood. The third would continue alive because it had been able to develop leaves. Iron spikes driven into trees were often grown over. He exhibited a specimen of English walnut wood, lent him by Messrs. Broadwood, in which the head of a long iron, used to fasten wire fencing, had been covered over with 3 in. of new wood. For all uses of any importance timber should be taken from the heartwood of a sound, well-grown tree. The grain should be close and firm, and should sound well when struck. The annual rings should be of even thickness, and the grain straight. It should be free from large or dead knots, shakes and blemishes. The chief defects found in a log of timber, besides those already mentioned, were—(*a*) cupshakes, which were gaping openings, forming segments of circles between the annual rings; (*b*) starshakes, cracks that ran toward the center of the tree; and (*c*) heartshakes, that opened in the center of the tree and spread toward the bark. If a heartshake were straight across the butt and ran up the log in a perfectly straight direction, it did no harm; but if it wound so as to get crosswise, by the time it got to the other end, the log was spoilt for most purposes. This tendency of the trunks of trees to twist was very curious. Most trees were subject to it; the Spanish chestnut in our country, the worst in this respect, twisted so violently, that by the time the tree was 60 years old it was usually badly torn by shakes, and began to decay at the heart. The lecturer did not think that this peculiarity in growth had been explained; but there were some very interesting facts in connection with the development of trees that seemed to bear on the question. However quietly a young tree might appear to grow, there was really a constant strain existing within it. The center of the stem was straining to elongate itself; the outer parts were holding it back. These forces, as a rule, balanced each other, so that they could only be discovered by experiment. It was easy to excite the fibers of a young plant in one place so that it would, of its own force, bend considerably out of the upright. Besides this, although a stem seemed to be growing regularly, there was a tendency to grow first on one side and then on another, so that a movement was set up such as was most strongly developed in the hop. When the stem of a large tree twisted without being affected by violent winds, it was evident that one of these forces connected with its growth had got the better of the other forces, so that the balance was not perfectly preserved. On the other hand, a young tree that had grown crooked sometimes altered its habits so as to make new wood in a straight and regular manner. When that was so, we found in the center of that log the crooked wood of the young tree.

Mr. Blashill continued: We next come to the questions of felling and preparation for use. The best ages at which trees can be felled are: for oak, 100 to 200 years; Scotch pine and Norway spruce, 70 to 100; larch, ash, and elm, 50 to 100; poplar, 30 to 50. The best time of the year for felling is the winter, because the tree is then most free from sap. Some trees may be felled soon after midsummer, because the sap is very quiet at that time. Oak is generally felled in the early spring—the worst time possible—because the bark, which is very valuable, is best obtained when the tree is full of sap. It is better to strip the bark off as the tree stands in the spring, and to fell it in the following autumn, when the sap has dried out of it. Teak is barked three years before being felled. It shrinks less than any wood in ordinary use, but it is said that this method renders the wood of teak more brittle. We have seen that the trunk of the growing tree is composed of wood in very different conditions. The interior is hard, comparatively dry, perhaps having its pores filled with resin or gum. The outer rings of wood are softer as they come nearer the bark, fuller of sap, more actively alive. Seasoning is the gradual drying of the whole log so that the shrinkage of the outer part shall not be so rapid as to cause it to split and tear open before the interior has had time to part with its moisture. If timber is to be seasoned without artificial help, it should be stored over a dry surface free from vegetation, well packed off the ground, with free access of air, but not exposed to much wind. When squared it should be stored under cover to give shelter from rain, sun, and wind. So treated, oak will require as many months as the side of the log measures in inches. Fir will take half this time. The timber should then be cut into plank or large scantlings, and be still further exposed to the air, being so stacked that it cannot warp or twist. When it is cut to the sizes for which it is required to be used, it is again stacked till it becomes fully seasoned. Finally, it should be brought into a dry, warm room or shop till it is fit for joiner's work. After it has been wrought it must stand in the shop for a few weeks, until it has assumed the average condition of dryness that is permanently maintained by wood in our moist climate. It may then be finished off. If a round or square piece of wood has to be made thoroughly dry, it is best to bore a hole through the heart, so that the air may get access to the interior, and make it keep pace in drying with the outside, so that the shrinkage will be really equal all through. The length of time that has to be occupied by this natural process of drying, with the consequent expense, has induced many inventors to propose the drying of timber by artificial means. The most ancient method is that of drying in the smoke, which would be the smoke of wood fires. Besides drying it more rapidly than could be done by the gentle warmth of a room, the bitter deposit from the smoke was supposed to protect wood from insects. There is an old patent (Langton's) by which the sap is extracted from the green timber in a vacuum cylinder under heat. The length of time occupied and the cost prevents its use. Other systems for the application of considerable heat with the condensation of the extracted moisture are subject to the grave defect of causing irregular shrinkage with splitting of the wood, and though the cracks thus made close again to a great extent, the mischief done to wood that is intended for many important uses is incurable. For the use of the carpenter it is unfortunate that balk timber and deals now seldom get any seasoning beyond the time requisite to convey them from the forest to the building, and the very imperfect seasoning the balks get during their stay in the docks. Such timber, if closed up from the air near to moist walls or new pugging, will quickly develop dry rot, even in the upper floors of a house. Deals should have a year or two of open-air seasoning, being stacked with spaces between them, and should afterward be gradually dried as they are required for use in the joiner's shop. Dry wainscot from Riga and Odessa are cut into thicknesses, and stacked for three, four, or five years, being placed on end, as the sap is supposed to run down more easily. Planks are stacked horizontally, with spaces between them. Such woods as mahogany, black walnut, ash, birch, and maple are treated similarly for a shorter time. In all cases the ends of timber require protection from sun and wind, as they dry more rapidly than the other parts. One of the old methods of seasoning is to keep timber in water for a fortnight after being felled. A good deal of the sap is thus dried out of it, and it becomes more durable, but is not so strong. Steeping it for a longer time injures it, particularly if it is kept floating only partly covered with water. Boiling and steaming timber have long been tried, and the processes have been almost or quite abandoned. The effect will be to wash out the sap as in steeping. A fresh plan of steaming has lately been introduced, and is said by some who have tried it to be efficient, as for many purposes it may very well be. There are many purposes for which the strength of wood is of less consequence than dryness, or at least permanence of the same degree of dryness. The sap has been extracted by the air pump, which must promote dryness; but this plan does not seem to have been much practiced. The ordinary means of drying artifically are various methods of keeping up heat in a drying room, generally by the use of waste steam from machinery. When wood has been cut up into small scantlings, the drying can be hastened in this way; but the further the heat is raised beyond that of an ordinary room the greater is the risk of irregular drying and overdrying.

There is a new process for seasoning boards by means of dry cold air. The air is passed through a furnace, so as to make it dry; it is next cooled, and then made to circulate through the piles of wood, so that in a few hours the boards are dry. One or other of these processes will probably be found so far satisfactory as to be useful for a great variety of purposes. There are no purposes for which wood is used in which the question of seasoning is of more importance than the higher class of cabinet work and the making of musical instruments. The best makers of such articles are exceedingly shy of artificial seasoning.

In organ-building such woods as mahogany, black walnut, birch, red, yellow, and white deal, and a large proportion of pine are used. These are stacked under cover, being carefully packed so that the air has free access through each stack. Hard woods require from two to four years; soft woods from one to two years of this seasoning after being cut to sizes. Even the workshop must not be too warm. The best pianos are made of wood that has been stored, first (as regards the deals) in open stacks protected from sun and the penetration of rain, and finally in rooms where all kinds of wood, cut to sizes, are subject to the very gentle warmth of 70°. The common sense of this question of seasoning is sufficiently obvious. Wood must not be dried so quickly that it will be made unsound by cracks. It must not be dried so much that it will absorb fresh moisture and swell when it comes into the atmosphere in which it has to permanently remain. It is not merely a question of time, but of judgment, the objects being to see that the timber is gradually reduced in scantling as it dries, and so treated as to temperature and stacking that it neither splits nor gets out of shape.

There is very great diversity in the details of different experiments on the loss of weight by seasoning. Oak appears to lose from something less than one-fifth to more than one-fourth of its weight. Other woods vary still more. Teak and pitch-pine lose very little. Woods that come from remote places get seasoned in a great measure before they reach this country. Paints or other appliances that would close up the pores must on no account be put on wood that is not sufficiently seasoned. When dry, they may be serviceable by preventing the absorption of moisture. If the wood is full of sap, decay will take place much quicker when painted than if it were left uncovered.

One of the most important questions, as regards the soft wood especially, is the prevention of decay. When in use in a building, timber generally decays either by rotting, through becoming sodden with wet, or by what is called "dry rot," which is caused by slight moisture, warmth, and want of ventilation. For the prevention of decay the kyanizing process, which consists of the application of corrosive sublimate by soaking, is effectual.

The process of Sir Wm. Burnett is still carried on by the firm established by him at Millwall. It does not seem that very much is required in order to make our resinous woods durable when exposed to the atmosphere. Complete exposure to the air, combined with the dryness of the ordinary atmosphere, is in itself a great preservative. Beech timber is useless in construction, as a building in which it is employed will be destroyed, chiefly through the attacks of insects, in a few years; but beech will last many years as a weather-boarding for such a building. In the Indies, such insects as the white ant destroy all woods that are not bitter, especially soft woods.

When furniture is sent from England, it may be partially protected by a coating of red lead; but if the insects get into the substance, they honeycomb it before any one suspects that they are there. It is, therefore, advisable to impregnate the wood with some protective solution, by means of such machinery as has been mentioned. The essential oils, such as turpentine, have been recommended; but they are inflammable. Corrosive sublimate, arsenic, and other poisonous solutions of that class seem most suitable. Creosoting is effectual both as against decay and against insects, but it spoils timber for all of the best and finest purposes. The protection of wood from fire is a most important question, particularly as recent experience seems to show that we cannot depend upon iron or stone. A heavy wooden beam will resist fire longer than any other beam or girder. The same with staircases. Such liquids as tungstate of soda could be forced into the substance of all wood used where fire is to be guarded against. Outward applications seem to be effectual in experiments tried on a small scale. To sum up the whole class of questions connected with seasoning, we want timber that will not shrink after it is brought into use, that will not warp or twist out of shape, will not decay through damp, and will not be destroyed by insects.

Wood may also be indurated, that being the result of polishing and of varnishing to some extent. Upon the whole, it is desirable to encourage all means of treating wood so that it may possess some of the advantages that are commonly attributed to iron and stone. In cutting up timber for use, the question of its grain as developed by the annual rings is of very great importance. The shrinkage being greater in the newer layers of wood, it must be cut so that this irregular shrinkage may be of no disadvantage in use.

* From a lecture recently delivered at Carpenters' Hall, London.

A plank taken out of the middle of a log will shrink at its sides more than in the middle; the boards that are cut out to right and left of this plank will curl outward from the center of the log. If a log is cut into four quarters, the part of each quarter that is furthest from the center will shrink the most. Nothing requires such care in converting as oak timber, in which the medullary rays have so much influence. In order to show the beauty of the grain, as well as to provide wainscot boards that will be true in shape, it is necessary to get the boards as far as possible to radiate from the center to the outside of the log. If this is done, the medullary rays are cut through in many places, so as to show the silver grain.

One method for doing this perfectly is shown in books, though I never heard of its being done in practice, the great expense and waste in sawing being an effectual obstacle. I have always had English oak "quartered," and then the boards have been sawn from alternate sides of each quarter—a method which insures at least eight perfect boards, and at least twice as many very good ones in regard of beauty of grain.

Wainscot oak from Riga and Odessa comes to this country with two slabs taken off the opposite sides, and a cut clean through the center, or else it has the slabs taken off and a plank taken out of the middle. When it is partly seasoned, the plank has the center part taken out, as the part around the pith is likely to be unsound. Then each of the side logs is cut up into boards, several of which will go pretty nearly along the line of the medullary rays, and show the silver grain.

Oak timber, as it was used in the beautiful Gothic timber roofs of the middle ages, and as it is still used in important parts of wooden ships, requires to be not straight, but bent. This bent timber is known as "compass" timber when it is 5 in. and upward out of the straight in a length of 12 ft., and is more valued on that account.

Ash timber does not appear to have any sapwood, all the wood being of the same color, and there are foreign timbers with the same peculiarity. It appears, however, that the worm finds out the part that is sapwood, so that it has the usual defect. In elm timber the sap is reckoned as good as the heart. The timber does not improve by seasoning, but should be used green, and even kept wet until wanted for use. When used in flooring, I have known the oldest elm boards shrink considerably if they were merely taken up and planed.

We must not overlook the important uses of the finer kinds of wood when cut up as veneer. The fact that veneer is very much abused is no argument against its legitimate use. It should only be used in panels, so that the framing will be of solid wood of good plain colors, to set off the beauty of the panels. The most beautiful veneers are still cut with the saw about ten to sixteen to the inch, though knife-cut veneers are very largely used. By steaming large logs of timber and putting them in a lathe, the knife will pare off a continuous sheet from the thirtieth to the one-hundredth part of an inch.

The chief woods used are rosewood, zebrawood, satinwood, tulipwood, mottled mahogany, walnut burrs, bird's-eye maple, birch, Hungarian ash, and sycamore, and there is a great variety of beautiful colonial and American woods producing every variety of color.

DESIGN FOR CHURCH AT WEST HERRINGTON.—Mr. A Hessell Tiltman, A.R.I.B.A., Architect.

CHURCH AT FRANKFURT.

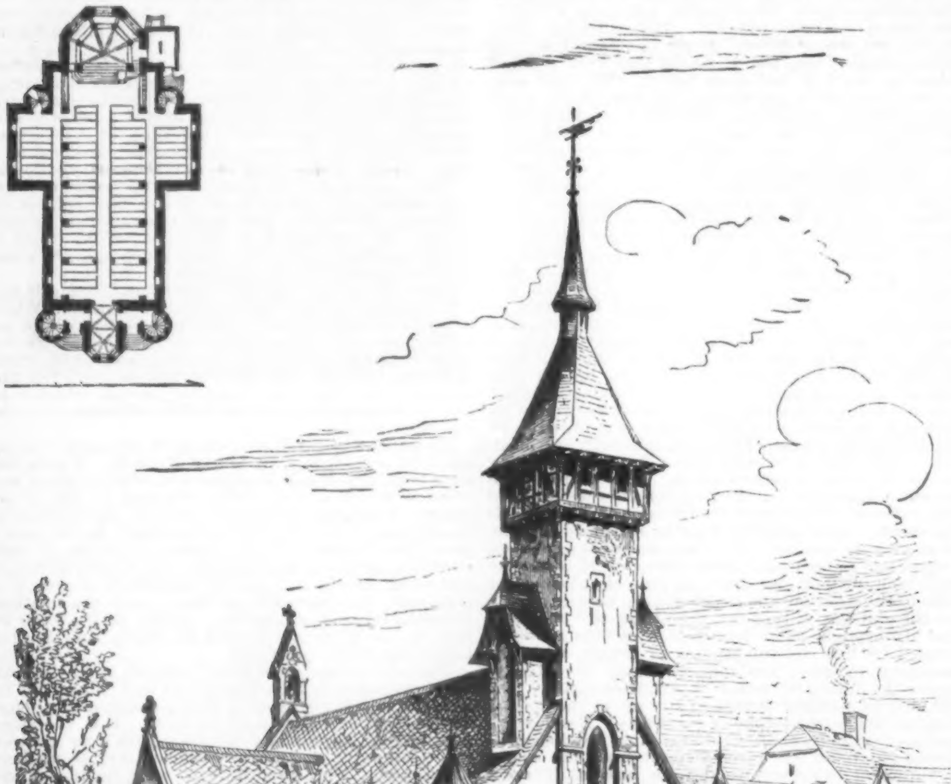
Christ Church, in Frankfurt a. M.; built by A. Von Kaufmann, architect, of the above mentioned city.

Christ Church was founded by Mr. Moritz Bernus, was built in the west end of the city, in 1883. As in the modern English churches, the six hundred seats are placed on the floor of the church in the nave and transepts; the choir is arranged for the accommodation of the singers only, the organ being placed in a part of the building constructed next to the choir, specially for its reception.

The principal entrances are in the tower, some, which serve also as porte-cocheres, being on one side, and others, for pedestrians, being on the other side.

The outer surfaces of the walls are of hewn Bockenheim basalt, and the quoins, lintels, sills and sill courses are of green sandstone, from the valley of the Alsen.

The entire cost of the church, including the furniture, but exclusive of the clock and organ, was 130,000 m. or about $31,000.—*Architektonische Rundschau.*



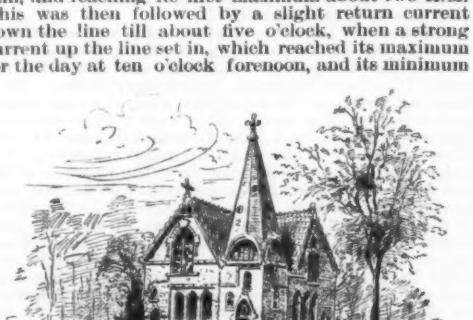
CHURCH AT FRANKFURT.—By A. v. Kauffmann, Architect.

DESIGN FOR A CHURCH.

The accompanying design was made for a proposed new church at West Herrington, near Durham, by A. Hessell Tiltman, London. The accommodation is for 500 persons, and consists of nave, two aisles, chancel, and the usual vestries. The material proposed to be employed was local stone with slate roofs.—*B. and E. Times.*

EARTH CURRENTS IN THE BEN NENIS OBSERVATORY TELEGRAPH CABLE.

At the last meeting of the Royal Society, of Edinburgh, a most interesting and suggestive paper on the above subject, by Mr. H. N. Dickson, was read by Professor Chrystal. Disturbance of the telegraphic instruments at the observatory by earth currents had frequently been observed, and the inference drawn from the disturbances was that the currents always existed, though with varying degrees of strength. Extending from about the middle of September till about the middle of October, 1885, a series of careful observations were made, with the view of determining, if possible, how far the disturbances were regular. By means of a galvanometer inserted in the telegraphic circuit, observations were taken every hour, and the results appeared to show that from midnight till four o'clock A.M. there was an earth current passing up the mountain, and reaching its first maximum about two A.M. This was then followed by a slight return current down the line till about five o'clock, when a strong current up the line set in, which reached its maximum for the day at ten o'clock forenoon, and its minimum at one P.M. Subsequently the current increased pretty rapidly down the line again till three P.M., and became rather unsteady during the next five hours. Then an uphill current steadily set in again, increasing till nine o'clock, and reaching it minimum at eleven P.M. While these observations were in progress, the summit of Ben Nevis was almost continuously enveloped in storm and mist, and by this the results were, to some extent, necessarily affected. When the top of the mountain was clear, it was observed that there was a strong current passing up the cable, the current being reversed when the opposite condition of things prevailed. The current was always found to be down the line during a fall of snow. In the opinion of Professor Chrystal, these results opened up an interesting field in electrical science, which could only be thoroughly investigated by help from Government. One thing required would be to obtain possession of a land line to make experiments as to the effect of earth currents along the horizontals. Mr. Sang said that the results detailed in the paper materially affected the results of the determination of the earth's density by means of a plummet. The deviation of the plummet on which those results were based might be caused entirely, he thought, by the presence of the currents spoken of.



SKETCH FOR A COUNTRY CHURCH.

THE SELF-INDUCTION OF AN ELECTRIC CURRENT IN RELATION TO THE NATURE AND FORM OF ITS CONDUCTOR.*

By Professor D. E. HUGHES, F.R.S.

INDUCED or secondary currents in a near but independent circuit were discovered by Faraday in 1831; and the phenomenon of the self-induction of an electric current in its own wire was observed by Henry in 1832, and traced to its cause in 1834 by Faraday, who proved that on sending a current through a wire a momentary induced current in the opposite direction is evoked in its own wire; also that, on the cessation of the primary current, a second induced or "*extra current*" is excited in the direction of the primary. The effect is greatly augmented when the wire forms a coil, as we then have in addition the reaction of superposed currents, but the effect exists to a great extent even when the wire forms but a single loop, or a straight wire with the earth forming the returning portion of the loop, as in all telegraph lines. It has been generally supposed that the nature of the molecular condition of the metal through which the primary current passed exerted no influence upon the extra currents except that due to its resistance. I have previously pointed out† that for induced currents "the rapidity of discharge has no direct relation with the electrical conductivity of the metal, for copper is much slower than zinc, and they are both superior to iron." This led me to make a study of these extra currents, for which purpose I constructed a special induction bridge, in order to measure both the primary and its extra currents separately at the instant of action.

Induction Bridge.—This instrument is a combination of a portion of my "Induction Balance," with a "Wheatstone Bridge." The resistance of the wire is

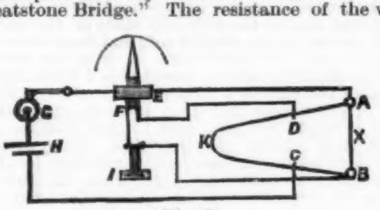


FIG. 1.

measured and balanced by the bridge; the induced or extra currents are measured and reduced to zero by an equal opposed induced current from the induction balance.

The above diagram shows the electrical communications. The bridge consists of a single German silver wire (0·25 mm. diameter, 1 meter in length, of 4 ohms resistance) running from A to K, returning to B. The wire is stretched and sustained upon two wooden arms articulated at K, by means of which the terminals, A B, can be more or less separated as desired. The wire to be tested, X, is joined at A and B, thus completing the closed circuit of the bridge. The external communications are shown, A being connected to the primary coil of the sonometer, E, and through it to the spring of the interrupter or rheotome, G, the interrupting wheel being connected to the battery, H, and thence to the bridge at C. The wire from B passes through the telephone, I, to the secondary coil, F, returning to D.

Great care has to be taken in the construction of the bridge, so that it shall be as free as possible from induced or extra currents; and for this reason we cannot employ or introduce resistance coils. The resistance of the wire, X, is balanced by sliding the communications, D and C. It is evident that if all the arms of this bridge are equal in resistance and inductive capacity, there will be silence on the telephone; but if A B be slightly stronger or weaker in inductive capacity, then we may be able to balance its resistance, but not its induction, as we shall then have a slight or a loud continuous sound due to the differential extra currents in the arm, A B. These are compensated by the introduction in the circuit of the telephone of an equivalent but opposed induced current from the secondary coil of the sonometer, F, the degree of angle through which this coil has turned to produce silence being the degree of force of the extra current. The induction sonometer‡ consists of two coils only, one of which is smaller and turns freely in the center of the outside coil. The exterior coil being stationary, the center coil turns upon an axle by means of a long (20 cm.) arm, or pointer, the point of which moves over a graduated arc or circle. Whenever the axis of the interior coil is perpendicular to the exterior coil no induction takes place, and we have a perfect zero; by turning the interior coil through any degree we have a current proportional to this angle, and in the direction in which it is turned. The value of the induction current for each sonometric degree was $\frac{1}{1000}$ of the primary current which passed through the wire under observation, the latter being variable at will from 0·001 to 0·250 ampere. There is also a reversing key (not shown in the diagram), in order to place the interrupter on the telephone circuit and close the battery current from H to A; the conditions then being the usual method of testing, except using the telephone in place of a galvanometer—a well known method. The telephone, being exceedingly sensitive and rapid, is most suitable, while a galvanometer would be too slow, and its use, in fact, impossible for the researches I have been making. Numerous details have been necessarily omitted in this rough sketch of the instrument. Suffice it to say that it is perfectly adapted for the object sought, viz., the investigation and measurement of the self-induction which takes place in all wires.

By all previous methods the measurement of the resistance of a wire is taken when the current has been already some time in action, or, to use an expression of M. Gaugain, when the electricity has arrived at its "stable period." In telegraphy, electric lighting, and all applications using rapid electrical changes, another period has to be considered, viz., that during the rise and fall of the current; this he named "the variable period," and it is in this period that all the phenomena of induction take place. To observe the *stable* period, the current is continuously passed through the bridge (and consequently through the wire under observation), and the interrupter being placed in the telephone circuit allows us to find the exact resistance of the wire, free from all induction or change in the wire itself. To observe the *variable* period, the interrupter or rheotome (making at will from 10 to 100 contacts per second) is placed on the battery circuit, the telephone being joined as shown in the diagram. By means of a switch or reversing key these changes are made as rapidly and often as desired.

If there were no static or self-induction, no loss of time, or change of resistance, then the result from these two periods would be equal; but this is never the case, for we find that when the resistance is balanced to a perfect zero for the stable period, loud sounds are given out in the variable period, requiring a fresh adjustment or balancing of the resistance of the wire, as well as a compensating opposing induction current from the sonometer to balance the self-induction. If we balance the resistance or the extra currents alone there is no possible zero, but when both are compensated we find at once a perfect zero for the resistance of the wire, and for its extra currents.

Inductive Capacity of Metals.—The results of the following experiments prove that the force and duration of the extra currents depend upon the kind of metal employed as a conductor, its molecular condition, and the form given to the conductor, independent of its resistance or the electromotive force of the primary current. The increase of force by increased length is proportional to the length of wire, less its additional resistance, but with wires of the same length increased cross section or diminished resistance does not produce a corresponding increase in the electromotive force of the extra currents. The time of charge and discharge of the wire is independent of the electromotive force of the extra currents; for, if we compare currents of equal electromotive force obtained from copper and iron, it will be found that the duration of these currents in wires of 1 mm. diameter will be seven times slower in iron than in copper, and a still greater difference will be found in larger wires. The longest or slowest charge and discharge take place in the purest soft iron, and have a constant ratio of increase with increased diameter of the wire; my experiments giving for wires of double the previous section, or for wires of four times less resistance, a mean increase of three times its previous duration. The electromotive force of the extra current in different metals will be seen in the following table, and in order that the values obtained from the sonometer may be clearly understood I have reduced the results to comparative values. The table of values was obtained on wires of similar length, having been repeated on a similar series of lengths ranging from 10 cm. to 5 meters. The instrument is sufficiently sensitive for pieces only 10 cm. in length, and the results from the short lengths were as pronounced and accurate as those for greater lengths. I may add that the instrument shows no effects or traces of stati charge for the lengths mentioned.

TABLE I.—Wires 1 mm. in Diameter, 30 cm. in Length.

Soft Swedish iron	100
Soft puddled iron	78
Swedish iron, not softened	55
Soft cast steel	41
Nickel *	34
Hardened cast steel	28
Cobalt *	24
Copper	20
Brass	13
Zinc *	12
Lead	10
German silver	7
Mercury *	2
Carbon *	1

The above table is only true for wires of 1 mm. diameter, as the effect depends on the size of the wire in relation to the nature of the metal. In soft Swedish iron a diminution in the electromotive force of the extra currents takes place with each increase in its section, and this has been partially foreseen by Maxwell,† who said: "The electromotive force arising from the induction of the current on itself is different in different parts of the section of the wire, being in general a function of the distance from the axis of the wire as well as time." From this I expected that the increase of electromotive force by an increased section would not increase directly as its sectional increase; but I was not prepared to find, as my experiments prove, that after a certain maximum diameter of wire has been reached a marked decrease in electromotive force takes place with each further sectional increase, and that this maximum is variable with each metal.

The diagram shows a rapid rise of force in soft iron from an extremely fine wire of 0·10 mm. section to a maximum at 1 mm., from which point there is a slow but continued decrease of force with each increase in the size of the wire, until at the comparatively great diameter of wire of 10 mm. the force is but a fraction more than in the extremely fine wire. Hard Swedish iron has a less initial force in the fine wire, and does not arrive at its maximum until the wire has 3 mm. diameter, being then nearly of the same force as soft iron of the same diameter; the fall from this point is somewhat similar, but less than soft iron until at 8 and 10 mm. soft and hard iron have absolutely the same values. A curious change of values at different diameters will be seen in copper and brass. Copper, having nearly double the initial force in fine wires, arrives at its maximum at 4 mm.; but brass creeps slowly up, passing copper at 5 mm., arriving at its maximum at 6 mm., and finally, in the large section 10 mm., it has more force than copper, their positions being completely reversed. I have been unable to obtain wires of different diameters of other metals; but zinc rods of 10 mm. gave a still higher rate than brass, while in small diameters its force was less. For non-magnetic metals it is probable that the greater the specific resistance of the metal the greater will be the diameter of the wire before the fall commences. Carbon is remarkably free from self-induction, and although there is a rise of force in rods of 3 mm. to 10 mm., it is so small as to be hardly measurable. German silver rises with comparative rapidity, indicating that with wires of 20 mm. its force would equal that of copper. Carbon therefore seems peculiarly adapted as a resistance when used in the variable period of electric currents.

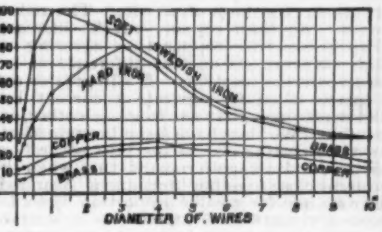


FIG. 2.

Influence of Parallel Currents.—The instrument being well adapted for showing the slightest change in the self-induction by the reaction of one portion of the current upon the other when in the same direction, as in a coil, or in the opposite direction, as in a parallel return wire, I made a series of experiments in order to observe the influence of different metallic conductors in this respect. Two silk-covered iron and copper wires of similar diameter and length (1 mm. diam., 2 meters in length) were each formed in a single loop of 66 cm. diameter. The extra currents from iron were, as usual, six times stronger than those from a similar loop of copper. On closing the loop by bringing the opposite sides in close proximity, and thus making a parallel return wire (the current ascending on one side and descending the other), I found that the reaction of currents in opposite direction was very different with different metals, the results depending more upon the nature of the metal than upon the proximity of the wires. There was a reduction of the previous force of the extra currents in iron, when forming a parallel return wire, of 15 per cent., while the reduction in copper was 80 per cent. Thus the currents in copper are far more influenced by an external wire than those in iron; consequently a telephone line having its return wire in close proximity should invariably be of copper, as not only is its specific inductive capacity less, but this is again reduced by the return wire, so that its self-induction is far below that of iron.

In order to observe the influence of currents in the same direction, the same wires were formed into a close coil of twelve turns of 2 cm. diameter; and from the known effects of parallel currents in the same direction we should expect a greatly increased effect. It was so in the case of copper, but iron was far less under the influence of an external parallel current; the strength of current in iron when formed into a coil being 57 per cent. greater than that of a single wide loop, while in copper the increase was 404 per cent., or seven times the increase of iron; and although iron when in a single wide loop had six times the force of copper, the comparative strength was reversed when the wires were wound as a coil, the extra currents from the copper coil then having 14 per cent. greater strength than that from iron, and this difference could be rendered more evident by employing longer wires. Thus copper, as regards extra currents, is far more sensitive to the influence of external currents than iron, and the true self-induction from its own current can only be obtained by a straight wire, where the return wire is at such a distance that its influence is not appreciable.

Reaction of Contiguous Portions of the Same Current.—It is well known that currents in separate portions of the same wire (as in a coil) react upon each other, and I felt convinced from the preceding experiment that self-induction is entirely due to similar electro-magnetic reactions between contiguous portions of the current in its own wire. Let us assume that an electric current consists of a bundle or an almost infinite number of parallel currents, the limit being a single line of consecutive molecules; then each line of current should by its electro-magnetic action react on each of the others similarly to wires conveying separate portions of the current, and the self-induction should be at its maximum when the lines are in the closet possible proximity, as in a conductor of circular section, and far less when separated, as in one of ribbon form, where the outlying portions are separated by a comparatively great distance. There would still remain, in the latter case, the reactions from the near portions on each other, and these should again be reduced by cutting the ribbon into a number of thin narrow strips, separated, except at their junction, to a sufficient distance to prevent any marked reaction.

My experiments prove that this assumption is an experimental fact, for we can reduce the self-induction of a current upon itself to a mere fraction of its previous force by simply separating as indicated the contiguous portions of a current from each other, the results proving that a comparatively small separation, such as is obtained by employing ribbon conductors in place of a wire of the same weight, reduces the self-induction 80 per cent. in iron and 35 per cent. in copper; and if we still divide the current by cutting the ribbon into several, say 16, strips (separating the strips at least 1 cm. from each other), then the combined, but separated, strips show a still greater reduction, being 94 per cent. in iron and 75 per cent. in copper. The following table shows the comparative reduction of self-induction by employing ribbons and parallel separated wires:

TABLE II.

Flat strips compared with round wire 30 cm. in length.	Copper.	Iron.	Parallel wires 30 cm. in length.	Copper.	Iron.
Wire 1 mm. diameter....	20	100	Wire 1 mm. diameter....	20	100
STRIPS.			SINGLE WIRE.		
0·25 mm. thick, 2 mm. wide....	15	35	0·25 mm. diameter....	16	48
Same, 5 mm. wide.	13	20	Two similar wires....	12	30
" 10 " "	11	15	Four " "	9	18
" 20 " "	10	14	Eight " "	8	10
" 40 " "	9	13	Sixteen " "	7	6
Same strip rolled up in the form of wire.. ..	17	15	Same, 16 wires bound close together.... ..	18	12

* Presidential address before the Society of Telegraph Engineers and Electricians.

† "Induction Currents Balance," *Proc. Roy. Soc.*, vol. xxix., p. 56, 1879; "Molecular Electro-Magnetic Induction," *Proc. Roy. Soc.*, March 7, 1881.

‡ *Comptes Rendus de l'Academie des Sciences*, Paris, Dec. 30, 1878, and Jan. 20, 1879; *Proc. Roy. Soc.*, vol. xxxi., p. 527, 1881.

* Being unable to procure wires of these metals, they were tested in the form of strips, and compared with similar strips of copper. Mercury was in a glass tube 2 mm. in diameter; carbon tested in the form of electric light carbon from 3 mm. to 10 mm.

† "Electricity and Magnetism," vol. ii., p. 291.

The resistance of a conductor, or even the nature of its metal, has less influence on its self-induction than the form given to that conductor, the 1 mm. wire in the above table having a less resistance than the strip of 2 mm. wide, and a greater than any of the wider strips; but through all these variations we notice a gradual fall from the wire to the widest strip or ribbon, with a marked return to its previous force when the ribbon is rolled up in the form of a wire. The reduction is greater in iron than copper, but its increase when rolled up is less than copper, thus agreeing with the previous observations on the difference of iron and copper to external reactions. A still greater reduction takes place when we separate a current by using parallel wires separated 2 cm. from each other, as shown in the table. We then have a similar reduction to that produced by cutting the strips into several separate conductors; and we again remark that when the wires are brought close together (forming a stranded wire), copper rises in a far greater proportion than iron, the 16 fine iron wires twisted together as a stranded wire having 88 per cent. less induction than a solid wire of similar weight; a remarkable fact being that while a solid iron wire has an inductive capacity 80 per cent. greater than a solid copper wire, this is completely reversed when each metal forms a stranded wire of the same weight as the solid, for iron then has 33 per cent. less self-induction than copper. It is not necessary to use extremely fine wires when we desire to reduce the inductive capacity of iron to that of copper, for I have formed wire rope of 16 strands of wire where each wire was 1 mm. in diameter, giving 75 per cent. less induction than a solid wire of the same resistance. I purchased an ordinary wire rope of 6 mm. diameter, having 6 strands of 6 wires, each 0·5 mm. diameter; this gave the best result yet obtained, for, on comparing 3 meters of it with a similar length of solid iron wire of the same resistance, the 36 stranded wire had only 5 per cent. of the amount of induction shown by the solid wire. Steel, in the form of ribbon or stranded wires, shows a similar effect to that of iron; and it is a remarkable fact that, while the extra currents from a steel or iron wire 4 mm. in diameter are extremely slow, and impossible to balance without reducing the time of the sonometer current (by the introduction of an iron core), the ribbon or stranded wire requires no such compensation, for its feeble extra current is exceedingly sharp, and can be balanced to a perfect zero, being actually quicker than that of a solid wire of copper of the same resistance. This fact I regard as one of greater importance for telegraph lines and lightning conductors.

A curious effect takes place if we employ mixed conductors, such as a compound wire of copper and iron. A fine coating of copper reduces the induction in a solid iron wire in a marked degree. This I found to be due to the difference of electromotive force of the extra currents in the two metals, for, by employing a fine copper wire parallel with an iron wire, and in contact at the ends, the extra current was reduced 60 per cent. The copper wire, having a lower electromotive force, probably acts as a shunt; but if the capacity of the iron has already been reduced, as in a sheet or stranded wires, then the addition of a single copper strand increases the force, as the electromotive force of the extra currents of copper is above that of stranded iron. There has been for many years a discussion as to the merits of the round form as compared with the tape or ribbon form for lightning conductors. Those in favor of the former based their conclusions on experiments which gave a negative or no apparent difference between the two forms of conductors. Those in favor of ribbon conductors, as Sir W. Snow Harris, Prof. Guillemin, and many others, based their opinion upon marked differences found when using high charges of static electricity. The latter supposed that there was a difference between discharges of static electricity and voltaic currents of low tension, and that the advantage recognized by almost conclusive experiments was due in a great measure to conduction by surface.

In the year 1864, Prof. Guillemin and myself, as members of the Commission de Perfectionment of the French Telegraph Administration, were charged with the mission of testing the comparative merits of the lightning protectors then used upon their lines. Our method of experimenting consisted in joining an insulated conductor to a short fine iron wire connected directly with the earth return wire. A Leyden jar battery charged by a Rhumkorff coil was discharged through this conductor, burning or deflagrating the fine iron wire. This wire represented the telegraph instrument requiring protection, and by placing the lightning protector connected with the earth in advance of the fine iron wire we could observe the amount of protection afforded. This answered extremely well for feeble discharges, but with the full power of our battery the fine iron wire was invariably destroyed, even with the best lightning protectors which are universally used to this day. Noticing that we could not give absolute protection to the fine wire by lightning protectors, we tried the effect of joining the conductor direct to a separate earth wire in advance of the fine wire, and with powerful discharges the wire beyond the protection was invariably burnt, notwithstanding that we connected the conductor direct to earth by a copper stranded wire of 1 cm. diameter. Prof. Guillemin continued these experiments after my departure for Russia, and he found, by employing a thin sheet of copper as a conductor to earth in place of the copper stranded wire placed in advance of the fine iron wire, that the wire could be perfectly protected. The theory of this action was not understood at the time, and the experiment has not received the attention it deserved; but the mutual reactions of contiguous currents shown in this paper explain the phenomenon in the fullest degree, for we see that a sheet or ribbon conductor has far less self-induction than a wire or rod of the same material.

I am fully convinced from the results of my experiments that an enormous retardation or resistance is evident in all conductors at the first portion of the variable period, and that this is due to self-induction, the current thus arousing an antagonist in its own path sufficiently powerful, when the primary current has a high electromotive force, to deflagrate or separate the wire into its constituent separate molecules, as shown by Dr. Warren de la Rue. It is also evident from my experiments—which are easily repeated, with invariable results—that a flat conductor has far less self-induction than a solid of circular section during the variable period; and even with a constant current, as in the stable period, this form of conductor, as first shown by Prof. George Forbes, would, from its greater radiation, convey more current with less heating than a wire or rod of the same resistance. Lightning conductors are intended to convey a current of high intensity during an exceedingly short time, and should therefore be designed so as to convey this current with as little opposition from self-induction as possible; consequently I regard a solid rod of iron as the worst possible form for a lightning conductor. The conductor, if of copper, should be of ribbon form, say 1 mm. by 10 cm. wide, or, if of iron, of numerous stranded wires or a wide ribbon of similar conductivity to that of the copper.

Self-Induction of a Telegraph Line.—A telegraph line may be considered as a single loop; the earth taking the place of a return wire can only affect the self-induction by a diminution of its effects, as in the case of a parallel return wire. Mr. W. H. Preece has lately read a most valuable paper on "The Relative Merits of Iron and Copper Wire for Telegraph Lines,"* in which he shows, by comparative rates of speed with the same instrument, that on a copper and an iron line of 278 miles in length (between London and Newcastle), whose resistance and static capacity were rendered equal, there was an increase of speed in the copper line of 12·9 per cent. as compared with an iron wire. I have not been able to test the relative speeds obtainable by telegraph instruments on wires of different material. The results in every case would depend very much on the apparatus employed, but I have considered the question from a point of view independent of the instruments. There is a remarkable difference in the resistance of a wire during the stable and the variable period, the measurements taken in the stable period giving no real or approximate idea of what its resistance really is during the rise of the current in the wire.

A curious fact in relation to telegraphy is that all measurements are made during the period of a constant flow of current, while all instruments—particularly those requiring rapid changes in the current—work only during the rise and fall of the current, as in the variable period. Telegraph engineers, however, have not made the mistake of assuming that there is no difference in the resistance of a wire in these two periods, as it is well known that electro-magnets and coils have a far higher resistance during the rise and fall of a current, and coils simply augment the effect of a straight wire of a given length. The present method of testing by Wheatstone bridge has been adopted because we had no practical means of measuring the resistance in the variable period; and I do not believe that this can be accomplished except by a similar method to that which I have used, in which the resistance and self-induction are separately measured and balanced, and by the use of an exceedingly rapid and sensitive instrument of observation, as the telephone, in place of the sluggish galvanometers, no matter of what construction. The speed of telegraph instruments is greatly influenced by the resistance of the wire. I said in 1883 † that a great difference would be found in the resistance of an electrical conductor if measured during the variable instead of the stable period, and I have made numerous experiments with the view of ascertaining to what extent this difference would probably be felt on telegraph lines. I have already mentioned that the time or the duration of the extra currents increases rapidly with the section of the conductor; consequently, comparisons can only be made between wires of similar section for speed, or wires of similar resistance for differences in their variable period. In measuring the resistance of a wire during the two periods, I have found it best to avoid the use of resistance coils, the simplest method being to measure or balance a given length of wire in one period, and then observing how much lengthening or shortening of the wire would produce a similar zero in the second period. Suppose that we commence by balancing the resistance during the variable period, and fix the sliding communications at the point at which we have obtained a perfect zero. We can now change to the stable period by means of the commutator; and as we no longer find a zero, but extremely loud sounds, we gradually lengthen the wire under observation until we have again a perfect zero. The amount of wire added to its previous length shows the difference in resistance between a conductor in which there are rapid electrical changes and that wherein the flow of current is constant.

Among numerous experiments I will cite a single example. I measured or balanced the resistance of an ordinary soft iron wire, 1 meter in length and 4 mm. diameter, during the variable period, and found that it required in the stable period exactly 2 meters 58 cm. to balance the previous resistance. Similar tests on a sample of best charcoal iron wire, as used on our telegraph lines, gave still more remarkable results, showing 225 per cent. difference between the two periods; for 1 meter of this wire had, during the rise and fall of the current, precisely the same resistance as 3 meters 25 cm. in the stable period. This shows that an iron telegraph wire has with rapid currents *more than three times* the resistance during its actual work than that supposed to be its true resistance. It was difficult on short lengths to find any change whatever in the resistance of copper or stranded iron wires in the two periods; the time of discharge being excessively rapid, I could only estimate the resistance by the electromotive force of the extra currents, or by forming the wires into coils (when a remarkably great difference is shown), and then estimating the proportional amount due to its own reaction. By this method I was enabled to detect 10 per cent. difference for a solid copper wire, and but 8 per cent. for the stranded rope of 36 iron wires. The difference in time of the duration of the extra currents between solid iron and copper and between solid iron and stranded iron is so great that we may consider a solid iron wire to belong, comparatively speaking, to the class of slow conductors, while copper and stranded iron would belong to the rapid.

I have shown a difference of resistance in the variable period between copper and iron of at least 200 per cent., a difference which will be felt on instruments depending upon rapid changes, such as the telephone; and it is evident that the more rapid the contacts of a telegraph instrument, the greater will be the difference between copper and iron. There is consequently a great electrical advantage in those instruments which require only a single current for each letter, as the economy of electrical impulses allows them to work at a comparatively high speed; the duration of the extra currents would be shorter than the length of their contacts, and consequently they would perceive very little, if any, difference between the two periods, or between iron and copper. If we use three or five currents for each letter, we must necessarily send them faster or closer together; and the difficulty increases in a rapid ratio with the speed of intermittent or reversed currents, until a point is reached (as I have shown in the case of best charcoal iron) where, while nominally working through 500 miles, we are practically working through an equivalent resistance of at least 1,500 miles, and this without taking into account the static charge, which would, in addition, from its comparatively extreme slowness of charge and discharge, cause the apparent resistance of the wire in the variable period to be much greater than I have mentioned. In Mr. Preece's experiments he finds a difference of speed of 12·9 per cent. between iron and copper, which is far less than the difference of resistance during the variable period which I have obtained; and this may be explained by assuming that the speed of the reversed currents which he employed was only near the border land of extra currents. I am convinced that if Mr. Preece could have increased the speed of the instruments, he would have found a far greater difference between iron and copper; and if I regard the results of a solid iron wire alone, I should consider iron as unsuitable for telegraph instruments requiring extremely rapid currents. Copper would reign supreme if it were not for the fact, which I have discovered, that stranded iron wires have even a greater rapidity of action than copper.

Physical Changes in the Conductor.—Self-induction not only depends on the nature and form of its conductor, but also on the physical state of the metal, as already shown in the case of soft and hard iron. I felt convinced that the higher force in iron was due to its magnetic capacity, and to prove this I tried the effect of heating the wire to a bright red heat, or 1,000 deg. C. It is well known that iron loses its magnetic properties at bright red heat, and I found that its self-induction then fell to less than that of copper. This would have been conclusive had it not been for the fact that a different result takes place when the capacity of the iron for self-induction has already been reduced, as in the case of thin flat sheets of iron; in this case there is no disappearance or further decrease of induction except that due to the extra resistance caused by the increased temperature of the strip. Now, as the strip was highly magnetic when cold, and lost this property at red heat, there should have been some change in its self-induction if this were due to the magnetic nature of the iron alone. This requires further researches before a probable explanation can be given.

Iron is peculiarly sensitive to all physical changes. Mechanical strain of all kinds hardens the wire, and its influence on its self-induction can at once be detected. An iron wire under a moderate longitudinal strain loses 40 per cent., and its capacity is then less than unstrained cast steel. Iron well annealed has much less resistance than the same iron when hard drawn, and soft iron is generally employed for telegraph lines; but during the variable period a curious reversal takes place, as then soft iron has a higher resistance than hard iron. This apparent anomaly is easily explained if we compare the far higher self-induction of soft iron. Work is done at the expense of electrical energy, and the apparent higher resistance is due to the greater electro-magnetic action in soft iron. An iron wire shows traces of remaining circular magnetism after the passage of a continuous current, reducing the following extra currents 10 per cent.

Magnetizing the wire, or subjecting it to mechanical vibrations, when used separately, produces no apparent change in its inductive capacity, but a remarkable change takes place if either of these is used in conjunction with a constant current. Let us pass a constant current and heat the wire to red heat, allowing it to cool with the current on; or, in place of heat, magnetize the wire; or, in place of magnetism, give the wire mechanical vibrations; the result of either of these being a strong internal circular magnetism, due, I believe, to the loosening of the magnetic molecules, allowing them to rotate with greater freedom under the influence of heat, mechanical vibrations, or magnetism. A wire thus treated has no longer its previous self-induction, which has fallen 60 per cent.; and as the circular magnetism becomes fixed when the vibrations cease, this molecular structure remains a constant as long as we employ intermittent currents in the same direction, but the structure disappears the instant a reverse current is sent; and this explains why we have more than double the amount of self-induction from reverse currents, as each reversal destroys any remaining magnetism due to the previous passage of the current. If we compare the electromotive force of self-induction on a given length of wire with the secondary currents generated in a second, but independent, circuit, we find that the self-induction is the most powerful, the secondary currents generated in a close independent copper wire being 20 per cent. less than its own wire. There is no difference between the self-induction of a current and the secondary currents; they are, in fact, as proved by Faraday, part of the same phenomenon. The self-induction is evidently due to the electro-magnetic reactions of the primary current, and as magnetism permeates space, the separation of the wire only serves to insulate the primary, but does not affect its magnetic influence; and, as I have shown in the reactions of contiguous portions of the same current, so the magnetic reactions perpendicular to the axis of the current continue through the wire to all surrounding wires; and if we call the currents in the independent wire secondary, they are still secondary while inclosed in the wire of the primary; and as the reaction will ever be the strongest in the axis of the current, so will these currents be necessarily stronger than those induced in independent wires. For this reason we should be able to obtain extra currents of far higher electromotive force than would be possible from a secondary wire of the same length. It was my intention, on the reading of this paper, to demonstrate by practical experiments some remarkable properties of extra currents of high electromotive force; but I find that the subject and apparatus employed require a longer description than the limits of this paper allow. I must also leave aside for the present my experiments

* British Association, Aberdeen, September, 1885.

† Discussion on the paper of W. H. Preece on Electrical Conductors, *Proc. Inst. Civil Engineers*, vol. lxxv., 1883.

upon coils of different forms with cores of different metals. These, as well as other results obtained, indicate that there is a large field of useful research in many directions, each, however, requiring special studies according to the object we may have in view. The record of numerous experiments, of which this paper is only an abstract, shows that the nature of the metal as well as its physical condition has an important influence upon the self-induction of an electric current, and by a study of the reactions produced by the contiguous portions of a current, and by application of the results, we may, as in the case of iron, transform an extremely slow conductor into one of the greatest rapidity; I therefore hope not only that these researches may be of interest from a scientific point of view, but that the results obtained may be of practical utility in some of the numerous applications of electricity.

ELECTRICITY APPLIED TO PHARMACY.

HOWEVER great care be taken by apothecaries in the dispensing of medicines, accidents due to material errors in putting up prescriptions will occasionally occur, and several of these were mentioned in the newspapers last year. Messrs. Schuch & Wiegel, of Berlin, have conceived the idea of using an electrical arrangement for preventing such mishaps in the future. As to principle, the arrangement resembles the burglar alarms that are connected with domestic call-bells. As shown in Fig. 1, it consists essentially of a pile, of a ball, and of a base provided with a metallic contact upon which the poison-bottle rests. Fig. 2 gives the details of the contact. This figure clearly shows that the bell begins to vibrate just as soon as the apothecary takes up a bottle containing poison, and this calls his attention to the fact.—*La Lumiere Electrique.*

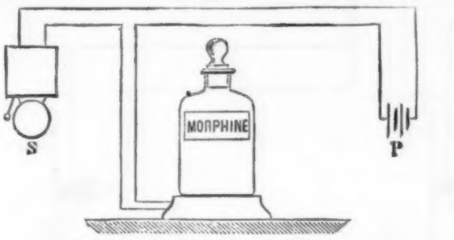


FIG. 1.

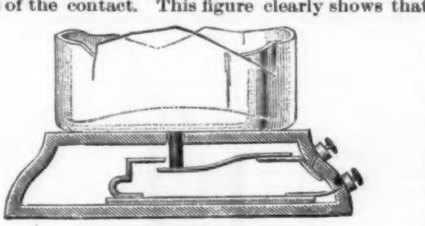


FIG. 2.

THE CONDENSATION OF FUMES BY STATIC ELECTRICITY.

A SERIES of extremely curious phenomena has been witnessed by us, and some experiments carried out by means of some apparatus constructed by Mr. Hempel have shown us the unexpected results of an electric discharge of high tension produced upon dust and smoke of every nature in suspension in a receiver. The importance of these scientific demonstrations, which will henceforth be capable of a very large number of industrial applications, is destined to make itself felt in the domain of practice.

Before entering upon a description of the instruments used for carrying out the experiments upon a small scale, we believe it well to advert to the history of the question.

Those who had occasion to be in London at the time of the heavy fog that enshrouded that city will readily understand the interest that is attached to a study of the nature of atmospheric dust and smoke. The subject has attracted the attention of several English physicists, and Prof. Lodge has pursued the study of it in a very original manner. At Paris we cannot obtain a very correct idea of what a fog may cost in London. On Thursday, Jan. 22, 1885, from midnight to midnight 1,016,640,000 cubic feet were delivered by the gas company. The fog was very heavy at this date, and so the consumption of gas was 37% greater than the normal quantity for the same day of the year. At the price then charged for gas, the public had to pay $26,000 more on account of the fog, as attested by a communication from the president of the company.

From the experiments of Mr. Aitken, we know that the aqueous vapor that forms clouds and fogs can condense in a vesicular state only around a solid particle of atmospheric dust. In support of his opinion, Mr. Aitken performed the following experiment: Two glass receivers were filled by him, one of them with ordinary air taken directly from the surrounding medium, and the other with air purified with great care and filtered through wadding.

Through cooling, the aqueous vapor in the first receiver condensed in the form of a fog, while the second receiver, despite the supersaturation of the air that it contained, preserved its transparency. In our opinion, this experimenter reaches conclusions that are by far too exclusive. He asserts that, without the presence of dust in the air, neither fog nor clouds would form, and probably no rain even.

In large industrial cities, in which the air is continually being inundated with factory smoke, every aqueous particle of the fog is invested with a tarry, oily pellicle which makes it heavier and keeps it in the lower regions, where its special character preserves it from immediate dispersion under the action of solar heat. The result of this is a heavy and persistent mist.

On the subject of dust in suspension in the atmosphere, it is not without interest to recall the elegant experiment of the learned Prof. Tyndall. A glass case, placed in a very dark room, was traversed by a powerful pencil of light. A brilliant trail, due, as well known, to the reflecting action of the solid particles thus illuminated, marked the passage of the rays of light. Under such circumstances, the introduction of a heated body into the box caused the apparition of a dark band above the warm body. This phenomenon indicated the complete absence of dust immediately above the heated object. Clark and Lodge, in studying the phenomenon as a whole, found that, around all bodies warmer than the atmosphere, there existed a thin zone of air that was practically free from dust. The theory that these experimenters put forth to explain the fact was founded upon calorific vibratory motions.

But electricity is likewise a peculiar mode of vibratory motion, and, by a very natural inclination, we should have recourse to its effects, especially to those that are characterized by a high tension. A few months ago, Mr. Lodge devised a memorable series of experiments, in which he succeeded, by means of charges from static machines, in causing a genuine conglomeration of particles of atmospheric dust and smoke.

A new field of research is opening up before persevering experimenters, who cannot be too strenuously urged to repeat and vary the conditions of demonstration. The apparatus that we are going to describe permit of this. They are simple and strong, and easily taken apart for carriage.

The one shown in Fig. 1 is designed for experiments upon smoke in a state of rest. A cylindrical glass receiver, having tubulures at the sides for the passage of the combs, A and B, which allow the electricity to flow, is placed upon a wooden tripod and provided with a central aperture. This receiver is surmounted by a small tube for quickening the draught after the necessary material for producing smoke has been placed in the stove, C, beneath the tripod. The combs, A and B, are connected by conducting wires with the exciting rods of a small Toepler-Voss machine, or else with a Holtz machine, or even an ordinary Ramsden one.

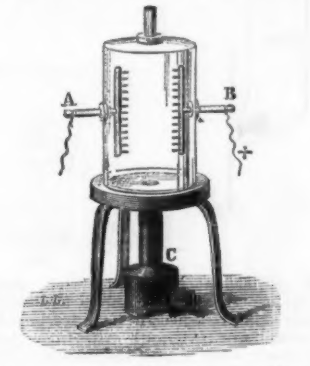


FIG. 1.—APPARATUS FOR CONDENSING FUMES.

As soon as the receiver is full of opaque clouds of smoke, due to the burning of nitrated paper, punk, or tobacco, or else derived from the vapors of chemical compounds, such as the action of hydrochloric acid upon ammonia, the electrical machine is set in motion. A very great commotion will at once develop; the smoke will curl in spirals, progressively condense, and finally disappear after a few seconds.

In order to facilitate the experiment, the receiver should be slightly warmed. After a certain period of action, the combs will become sticky to the touch, in consequence of the deposits due to condensation, and may be easily taken out of the receiver, and, along with the latter, be cleaned with a sponge.

For experimenting upon smoke in motion, the apparatus is given the form shown in Fig. 2. In the stove, M, are burned the materials for producing an abundance of smoke. The chimney of this stove enters the base of an oblong, vertical box, two of whose opposite sides are of wood, while the other two are of glass that permits of an observation of what is going on within. In this box there is a series of combs, P, P, P, placed in pairs opposite one another, and the handles of which end externally.

FIG. 2.—APPARATUS FOR CONDENSING FUMES.

We shall remark, incidentally, that the relative positions of the combs are arbitrary. We can adopt the cross, circular, or any other arrangement deemed proper. In the case under consideration, they are so fixed as to permit an observation of the phenomena at the lower, the central, and the upper part of the receiver. In this latter part, the products of combustion meet with a horizontal glass tube, T, about four and a quarter feet long, and of an internal diameter of 2¼ inches.

This tube enters a box similar to the other, lying horizontally, and containing nothing but a pair of combs. It is surmounted by an escape pipe, the section of whose draught is varied by a damper, R. In order to quicken the smoke's ascent, a gas burner is introduced into the side of the pipe.

For experiment, the combs are connected with electrical machines. The damper, R, at the base of the chimney permits of regulating the draught, and of keeping up the flow of the gaseous current between definite limits. With this arrangement of the apparatus, the course of the phenomena is easily followed.

We have experimented with fumes of various nature, especially with those derived from the reaction of hydrochloric acid upon ammonia. As soon as the vertical box is filled with these, the electrical machine is set in motion. After a few seconds of operation, flocks of agglomerated hydrochlorate of ammonia will deposit upon the combs, and the sides of the box will at once become coated with the same. A portion of the vapor, which has not perceptibly undergone the effect of the electricity, will be carried along through the tube, T, into the second box, where it will again be submitted to the influence of another electrical machine. Deposits will occur here likewise, but, as might have been expected, not in a great abundance; and a small quantity will be diffused as far as to the chimney. At the external orifice of the latter, but a few white threads will be faintly perceived, instead of the ordinary white, plume-like vapor; and these would soon entirely disappear upon the power of the electrical machines being combined in accurate proportions with the energy of the draught.

Prof. Lodge has been so fortunate as to see his startling experiments in pure science find an immediate application in the metallurgical industry of England. This is a remarkable circumstance, and one rare enough to have attention called to it.

In view of the encouraging results of this discovery, Mr. Walker has decided to apply it industrially in his lead works, where condensation of the fumes has a twofold purpose, viz., to suppress the unhealthy influence that they have on man, animals, and plants, and to collect the often large quantity (as much as 12 or 15 per cent.) of lead that they carry along. The plumbeous matter thus carried along consists not only of pulverulent slicks, but, also, of oxidized materials in a state of so extreme division that it is difficult to cause them to deposit.

Various methods have been employed with a view of obtaining results proportionate to that increase of expense which so encumbers the production.

In sufficiently extensive works, the process generally adopted consists in passing the fumes into pipes of quite wide section and of considerable length (often a mile or two), that end in a draught chimney. One can easily fancy what difficulties and what an increase of expense such a treatment occasions; and, whatever be the process, the condensation is always imperfect.

In the opinion of the promoter of the new process, the use of powerful induction machines will permit of obtaining a production much greater than that yielded by the old systems of condensation.

What has been tried for lead can likewise be tried in other metallurgical operations, with zinc-white, arsenic, etc.

The artificial purification of the atmosphere of works in which deleterious and insalubrious materials are handled, the ridding of places of accumulations of odors and dust, the treating of the opaque fumes and tarry products of gas works, and the rendering of the vitiated air of railroad tunnels healthy, constitute a vast field of experimentation for workers who have the good fortune to have laboratories and various instruments at their disposal.

There is one question of great interest, from a humane point of view, that we desire to likewise call attention to: we refer to the explosions of dust in mines subject to fire-damp. In order to avert these, recourse has been had up to the present to several more or less efficacious means that have been extolled by mining engineers connected with seats of exploitation. Ozone must, to a certain degree, co-operate to render such accidents graver. When cold, it burns organic substances, and these slow combustions, latent so to speak, probably occur in the midst of the dust deposited upon the timber work. Well, then, could not an attempt be made to clear the soles of galleries by processes analogous to those which we have described for lead dust? Who knows? It is true that the experiment presents itself under conditions that are particularly difficult of realization—this we recognize. We shall not despair of seeing it tried, and those who will devote their efforts thereto will deserve to be ranked among the benefactors of humanity.

With what causes must these phenomena of condensation be connected? For the time being, this question has not received a satisfactory answer, and we are reduced to conjectures concerning it. One of the most plausible hypotheses consists in admitting that, as a consequence of the forces brought into play in the development of electricity, rotary couples form under the latter's reciprocal action that bring about a special directing of the corpuscles, which latter rush toward each other and become agglutinated into small masses, whose heaviness quickens the deposit.—*E. Dieudonné, in La Lumiere Electrique.*

A REMARKABLE THUNDERBOLT.

THE *Zeitschrift fur Elektrotechnik* says that on the 30th of July, 1884, at half-past five in the morning, during a heavy storm accompanied with hail (some of the stones of which were as large as a hazel nut), the lower pane of glass of a window in the first story of a house located opposite the church in Ribnitz was suddenly pierced by lightning. A jet of water coming from below entered the room, shot up to the ceiling, and tore off a large piece of plastering. The water and plaster fell upon a small cigar table and broke it. The room was inundated to such a point that three pailfuls of water were gathered up.

Several reasons lead to the belief that a flash entered the room at the same time. In fact, the hole made in the glass, and from whence cracks radiated in every direction, presented the same appearance as if it had been made by a ball. Underneath the aperture the the glass was wet. It is not probable that a jet of water

alone could have been able to produce such an aperture. Some cigars that chanced to lie in a cup on the table were set on fire.

The inhabitants of the house affirm that an instant previous to the entrance of the water they saw a flash of lightning and heard a simultaneous clap of thunder.

SOME RECENT TELEPHONE APPARATUS.*

BURNLEY'S carbon telephones exhibit some interesting peculiarities. In the apparatus shown in Fig. 1, the variations in contact between the two carbon

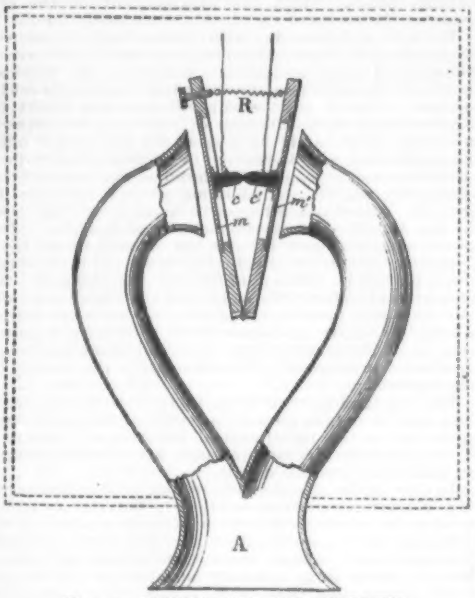
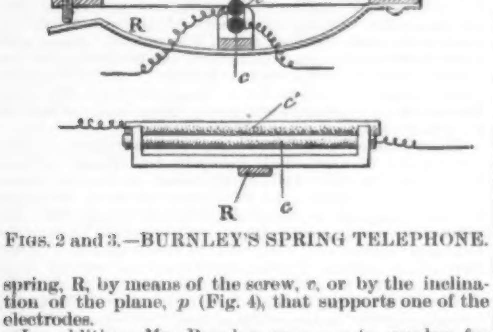


FIG. 1.—BURNLEY'S TELEPHONE.

electrodes, c and c', are effected through the vibrations of the two diaphragms, m and m', which are likewise influenced by the sound emitted at the mouthpiece, A. The intensity of the contact of the two electrodes is determined by the tension of the spring, R, which can be regulated at will. Sometimes the space between the diaphragms is filled in with a sort of cushion of cotton wadding, in order to deaden the abnormal vibrations of their opposite surfaces, without injuring the effect of the sounds that strike their external surfaces more directly. According to Mr. Burnley, this telephone is extremely sensitive. In Figs. 3 and 4, sensitiveness is secured by the length of the contacts of the electrodes, c and c', which bear, through their generatrix, with a force that is determined by the regulation of the



FIGS. 2 and 3.—BURNLEY'S SPRING TELEPHONE.

spring, R, by means of the screw, v, or by the inclination of the plane, p (Fig. 4), that supports one of the electrodes.

In addition, Mr. Burnley proposes to employ for multiple telephony a sort of transformer, which is shown in diagram in Fig. 5, and which consists of a series of bobbins, each of the very coarse primary wires, p, of which directly receives the circuit of the telephone pile, P, which it converts into a current of high tension, through the very fine secondary wires, s, connected with each other and the line by the wires, d. The diaphragms of the various telephones branched

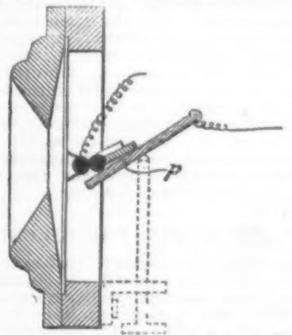


FIG. 4.—BURNLEY'S INCLINED PLANE TELEPHONE.

upon the same transformer must be grouped in such a way as to be identically impressed by the sounds that they transmit.

Mr. Dejongh's microphone transmitter is more remarkable for its simplicity than for the novelty of its principle. The current passes from the plate, c' (Fig. 6), to the supports, c'', through the very light carbon cylinder, c, whose contacts vary with the vibration of the plate, m, in front of which the speaking is done. Mr. Dejongh claims in favor of his apparatus, aside from its plainness, the facility that it offers of mounting a large number of transmitters upon a single plate, m.

Mr. Hibbert Johnson, in his piston telephone (Figs. 7, 8, and 9), prefers to employ two platinum contacts, b and c, whose movable electrode, b, is connected with an armature, E, which changes place in front of the electro-magnet, C, when one speaks at F. This armature carries along with it a very light hollow

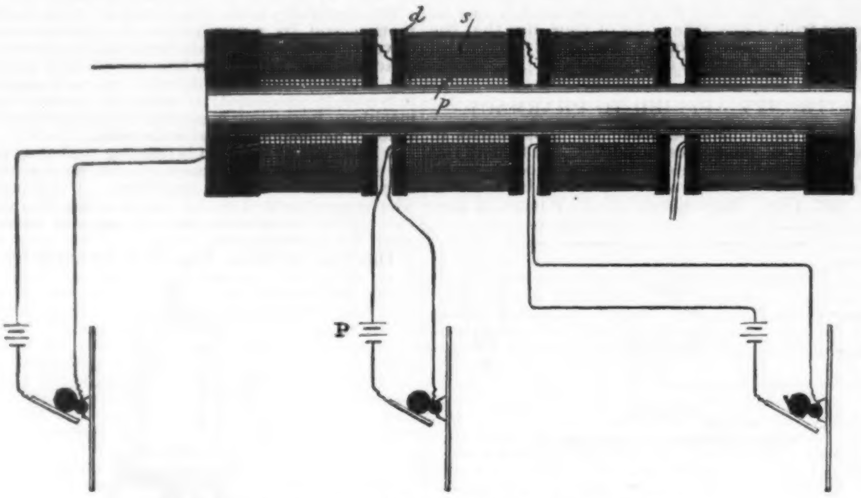


FIG. 5.—BURNLEY'S MULTIPLE TRANSFORMER.

piston, D, which is carefully guided, and is closed beneath so as to imprison above the electro a small bulk of air that balances it, and deadens the motions of the armature without altering their nature, thanks to their very slight amplitude. The wires of the electro, C, are, as may be seen, connected with the circuit by the screws, d and c, and the latter of these is also directly connected with the contact, c, by means of the electro, while the former (d) ends, through the rings, f and g, and the rod, h, in the socket, l, and the wire, i, of the armature, E. The bobbin of the electro is thus put into short circuit, through the very contact

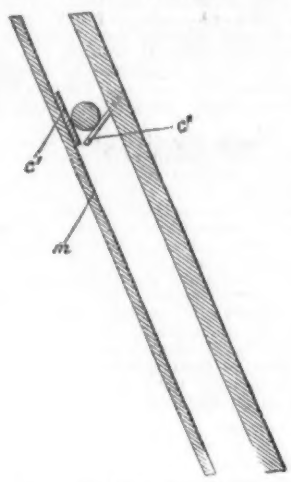


FIG. 6.—DEJONGH'S TRANSMITTER.

of the platinum electrodes, in such a manner as to prevent them from separating too easily; and such separation introduces into the current, through the wire, l, a determinate resistance. When the electrodes separate, there develops in the electro wires a counter electromotive force, which diminishes the intensity of the line current, and increases the sensitiveness of its variations. The object of the apertures, a, is to weaken the pulsations of the sonorous waves upon the piston, D.

Mr. Johnson's telephone is certainly worthy of attracting attention; but it is to be feared that the friction of the piston, however slight it be, may intervene to cause trouble in its operation.

The bobbins of the Burnley telephone (Fig. 10) are peculiarly wound, the wires turning back abruptly at C, at the end of each winding, so that all the windings begin at the same end of the bobbin. Near the middle of the winding there is interposed a series of bundles of wires, f (Fig. 11), which are parallel with the bobbin's axis, and end very near the diaphragm, m. The permanent magnet, A, consists of three juxtaposed strips of metal, the central one of which slightly exceeds the two others. In addition, it carries two polarized branches, A', against which the extremities of the diaphragm and the bundles, f, bear. The winding of the wire bobbins is such that the direction of the currents shall be always the same in the magnet, A, and in the bundles, f, so that their polarity is always contrary to that of the diaphragm.

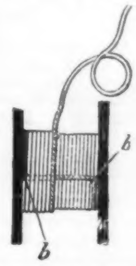


FIG. 10.—BOBBIN OF BURNLEY'S TELEPHONE.

In order to increase the telephone's sensitiveness, Mr. A. Price proposes to place behind the diaphragm, m (Figs. 12 and 13), a chamber, C, in which there is a vacuum to prevent the pressure of the air to exert itself upon the back of the diaphragm; but it is difficult to explain the reason for such an arrangement, which, *a*

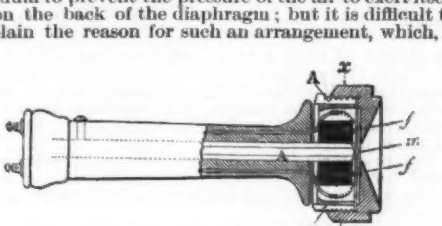
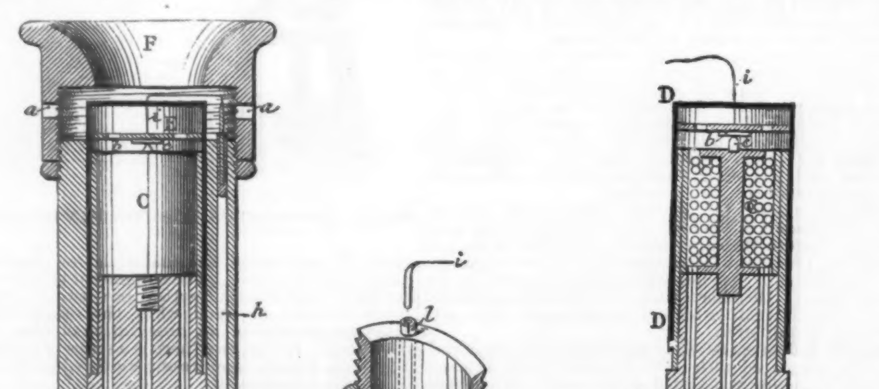


FIG. 11.—BURNLEY'S TELEPHONE.

priori, appears to have no other advantage than that of protecting the microphone contacts, m', against access of dust. Mr. Gerrish Farmer's telephone relay is remarkable for some well studied details of construction. The transmitting apparatus consists of a lever, A (Fig. 14), which oscillates around an axis, b, and is divided into two insulated halves that carry at each extremity an arrangement, B' and C', whose contacts



FIGS. 7, 8, AND 9.—JOHNSON'S PISTON TELEPHONE.

* *La Lumière Electrique.*

with a' vary according to the amplitude of the oscillations given the lever, A, by the vibrations of the diaphragm. The strips, B and C, are connected with the local circuit, E', whose branches wind in opposite directions around the induction coil, I. The primary wire of the latter is connected, through F', with the electro, B, of the relay, to which it thus transmits undulatory currents, a function of the diaphragm, D'. The electro, B, then causes the oscillation of the polarized armature, C D (Figs. 15 and 16), and of the strips, K K', which are connected with the circuit, H', of the relay, in which they act like the strips, B' and C', of the circuit, E' I F', of the transmitter, whose greatly re-enforced currents they thus transmit.

As may be seen in detail in Figs. 15 and 16, the extent of the vibrations of the armature, C D, is limited by the distance apart of the screws, e; and the ring, m, permits of regulating their sensitiveness, while the screw, a, allows the poles, c, of the electro, B, to be brought to within variable distances of C. The very light aluminum strips, K K', are more or less drawn by the insulated piece, M, according as the armature, C D,

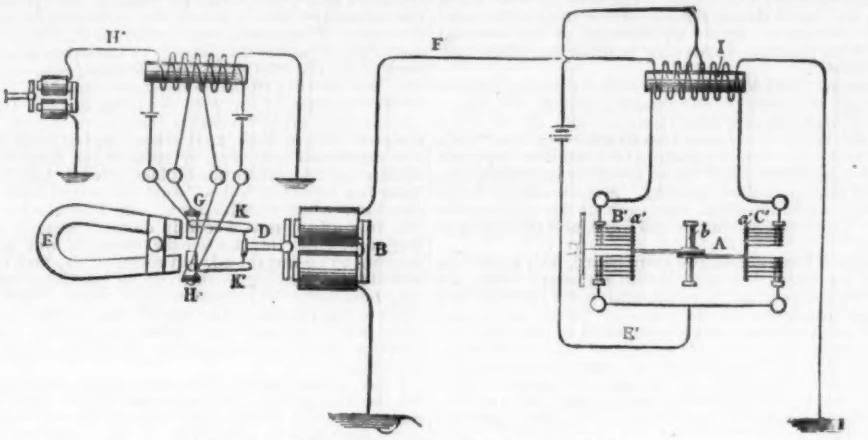
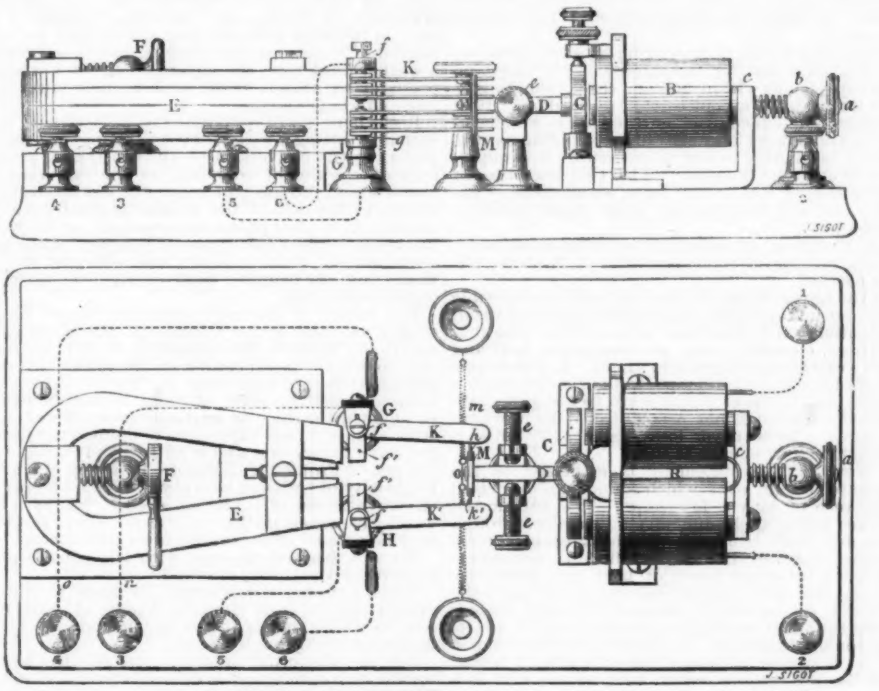
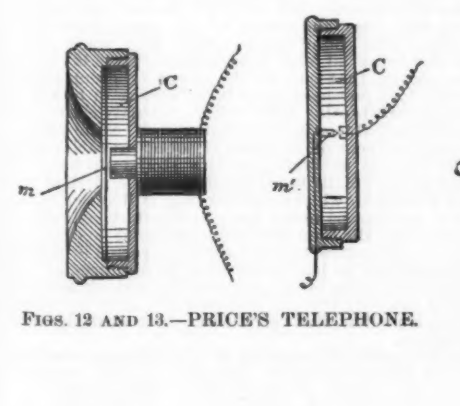


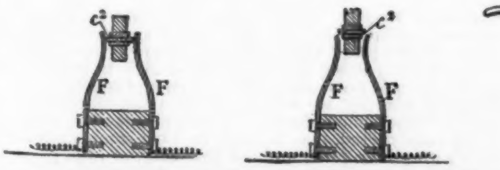
FIG. 14.—FARMER'S TELEPHONE RELAY.



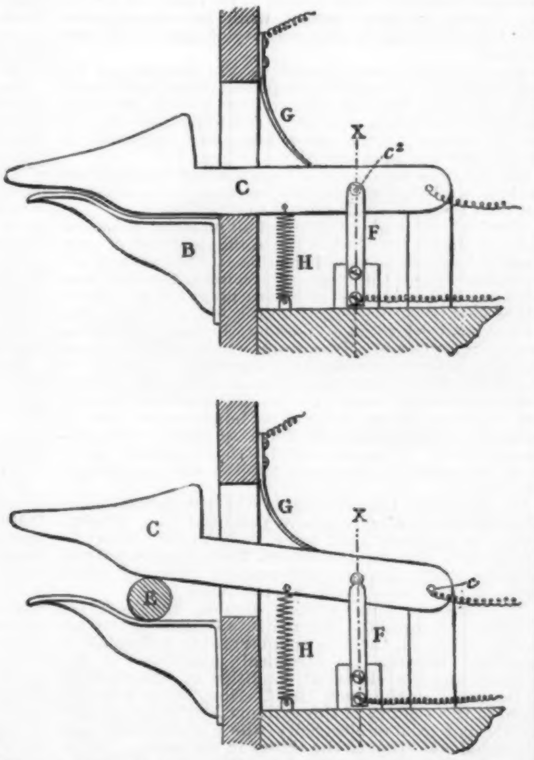
FIGS. 15 AND 16.—FARMER'S TELEPHONE RELAY.—ELEVATION AND PLAN.



FIGS. 12 AND 13.—PRICE'S TELEPHONE.



FIGS. 19 AND 20.—SECTIONS CORRESPONDING TO THE POSITIONS SHOWN IN FIGS. 17 and 18.



FIGS. 17 AND 18.—BALLARD INTERRUPTER CLOSED AND OPEN.

makes them oscillate around their joints, h, k', and f. The object of the permanent magnet, E, is to maintain a certain pressure of the strips against the knife edges, h and k', through its attraction, which may be regulated by moving it by means of the screw, F. Each of the strips, to this effect, carries a small rectangular piece of iron, f, to the right of the poles of the magnet, E. The relay shown in Figs. 15 and 16 is provided with six terminals. Of these, 1 and 2 are connected with the electro, B, and the transmitter; 3, with n, through the bottom, G; and 4, through the wire, o, with the pivot, f, of the strips, K, insulated from G; so that the current passes from n to o through f, the strips, K, M, K', and the button, G. The terminals 4 and 6 are connected with the same button, H.

The use of a double play of six strips, K, permits, thanks to the multiplicity of contacts, of securing efficiency, and, in addition, offers the advantage of dividing into two the variations in their contacts simultaneously upon two points of each of the circuits of the relay.

Mr. Ballard's interrupter (Figs. 17 to 20) causes the current to pass through cc^2 and F into the telephone, when the ring, E, is removed from between the jaws, C and B. The current, on the contrary, passes directly to the call, through CG, when the ring is introduced between the jaws of the interrupter. This is a very simple device, but one which scarcely seems to offer any great advantage over those which act through the weight of the telephone instead of the spring, H.

ON THE VARIATIONS OF THE ABSORPTION-SPECTRA AND THE EMISSIVE PHOSPHORESCENCE-SPECTRA OF ONE AND THE SAME BODY.

By M. HENRI BECQUEREL.

RESEARCHES now in progress have led the author to suppose that the absorption of radiations by different substances is due to the existence of synchronous vibratory movements of the absorbed radiations—movements which may take rise under the influence of these radiations, and which may have their seat either in the molecules of the bodies or in the intermolecular ether. In certain substances these movements give rise to phosphorescence.

This hypothesis leads to the consequence that in one and the same absorptive substance, placed in different media, the internal vibratory movements will no longer have the same rapidity, and that consequently both the absorption-spectra and the emission-spectra will be different. We may even foresee that the cause which retards the propagation of light in the interior of various media may have an influence of the same kind upon the time of the periods of the intermolecular movements, and that if we dissolve in various liquids one and the same substance presenting absorption or phosphorescence bands, the latter will correspond to movements so much the slower, and so much the more displaced toward the red, as the indices of refraction of the solution are greater. We find thus, *a priori*, a general conclusion which has been deduced experimentally from numerous observations made by different physicists. The author has verified the generality of the fact with different substances in different solvents. Every chemical modification of the substances gives rise in the spectra to modifications which will not be examined in this paper.

The influence of the variation of the indices of refraction upon absorption is distinctly shown in solutions of one and the same body of different degrees of concentration, and observed in layers of different thickness, so that the absorption-bands always retain the same aspect. Thus for a strong solution of didymium nitrate in water, the refraction index of which corresponding to the middle of the strongest absorption-band is $n = 1{\cdot}4388$, the mean wave-length of this band is $\lambda = 579$. In the same solution diluted with water we have, for the same band, $n = 1{\cdot}3454$ and $\lambda = 574{\cdot}5$. We thus see that for solutions of different strength of one and the same body, in one and the same solvent, the absorption-bands do not occupy the same place in the spectrum, since the index of refraction varies with the concentration.

These considerations apply to crystalline media. In a double refractive crystal, giving an absorption-spectrum, the two rays have not the same indices of refraction; the absorption-spectrum corresponding to them should therefore be different, and in this point of view all the double refractive crystals are polychroitic. In 1866 Prof. Bunsen observed that the absorption-spectrum obtained through a crystal of didymium sulphate varies slightly if studied in polarized light according to the different directions. Mr. Sorby has since observed an analogous fact in the uraniferous zircons. At the conclusion of an investigation on the relations between absorption and dispersion, Dr. Kundt advanced the idea that in birefractive dichroic substances the absorption-bands of that of the two rays which has the greatest dispersion ought to be in the spectrum, nearer the red than for the other ray. Observation does not entirely agree with these views, which, as far as crystals are concerned, are not based upon direct experiment. The natural crystals in which absorption-bands have been recognized are parisite, monazite, various apatites, scheelite, and various uraniferous zircons. To this list may be added leucophane, melinophane, and the bacillary strontianite from Scotland, in which the author has detected didymium. The absorption-spectra of these latter substances in natural light are composed of very fine bands, variously grouped, corresponding to the following wave-lengths:

Scotch strontianite—588, 584·5, 580·7, 577·5, 573·5, 570·3, 567.

Leucophane—599, 593, 589·2, 585·5, 582, 578·2, 573·5, 528.

If we fuse leucophane, the group of fine bands is replaced by diffused bands.

If we study the various crystals above mentioned in polarized light, we see the absorption-spectra change with the direction of the crystal.

Let us examine at first the phenomena presented by uniaxial birefringent crystals. We may mention as type the spectra of scheelite in which M. Cossa had detected didymium. The mean wave-lengths of the bands of the absorption-spectra are the following:

Ordinary ray—593 (trace), 588·5 (trace), 585 (strong trace), 579 (trace), 573·5 (strong trace).

Extraordinary ray—596, 593, 588·5, 586, 585, 579, 578, 573·5.

The other crystals give results of the same order.

We deduce from observations made in different directions that in uniaxial crystals the absorption-spectrum observed in any direction whatever is formed by the superposition of two series of bands corresponding each to each of the principal directions of elasticity of the crystal.

The spectrum of the ordinary ray gives one of these series of bands which constitute the ordinary spectrum. For the extraordinary ray, the bands displace each other only when the index varies with the direction of the ray, but the spectrum is formed by the superposition, in varying intensity, of the two series of bands just mentioned. In order to isolate completely the extraordinary spectrum, the author is having crystals cut in suitable directions. In the direction of the axis the two spectra appear superposed, and only vary in intensity when the azimuth of the plane of polarization of the light is varied.

In biaxial crystals the phenomena appear more complicated, and we may foresee the existence of three absorption-spectra corresponding to the three axes of elasticity.

We may expect to find analogous variations in the phenomena of phosphorescence presented by crystals. Among phosphorescent crystals, where the author has recognized changes in the absorption-spectra, may be mentioned the salts of uranyle and in particular the double potassium-uranyle chloride, the very remarkable variations of which will be shown in a future memoir. Experiment has shown that in polarized light the phosphorescence-spectra of crystals do not appear to present any appreciable change, and seem the same as in natural light. If there are several phosphorescence-spectra corresponding to the principal directions of the elasticity of crystals, as it is probable, it has not been possible to separate them, because the vibrations emitted by phosphorescence are not capable of polarization.

The facts expounded in this note give the explanation of the following phenomenon:

When a body absorbs or emits vibrations which seem as if they ought to be harmonic, these are affected by a perturbation which tends to approximate the absorption or emission bands in proportion as they are more refrangible. In fact, for the same body, the index of refraction varying regularly by the fact of dispersion, each band must be displaced from the theoretical position which it should occupy and be removed so much the more toward the red as the index of refraction is greater. The successive bands must then tend to draw more closely together from the most refrangible side, as observation shows. It is possible that a cause of the same order intervenes to determine the successive positions of the emission rays of incandescent vapors.—*Comptes Rendus* (vol. cii., p. 106); *Chem. News.*

A NEW THEORY OF SOUND.

By HENRY A. MOTT, Ph.D., F.C.S.

IT is a well known fact that our senses have only a certain narrow guage within which they are able to bring us into sensible contact with the world about us. All outside of this range we are unable to reach, except in so far as artificial means have assisted us.

For example, we do not see all forms and colors; we do not hear all sounds; we do not smell all odors; we cannot consciously touch all substances; we cannot taste all flavors.

The owl and the bat can see when we cannot, the hare can hear sounds which would pass by us unheard, and the hound can scent an odor which we can only know the existence of by our higher faculty of reason.

We must not imagine, therefore, that because we cannot hear sounds in what we call perfect stillness, there is no sound. The fact is, had we ears more sensitive, we would be continually surrounded by noises or sounds on all sides; in fact, by sounds of deafening intensity on the one side, and sounds of far less intensity than are produced by a fly when walking, on the other side.

It is evident that the limitations put to our sense of hearing are quite essential for our comfort and happiness.

It it a fact that when our organs of hearing receive on the one side less than 16 pulsations in one second, and on the other more than about 40,000 pulsations, we will fail to hear sound; between these limits, however, we can hear all sounds when of sufficient intensity.

In presenting the NEW THEORY OF SOUND, or more properly the SUBSTANTIAL THEORY, it will be necessary to set forth as briefly as possible an outline of the PHILOSOPHY OF SUBSTANTIALISM, founded by A. Wilford Hall Ph.D., LL.D., and such other facts deduced from experiment, observation, and reason as bear more or less directly on the subject, when the substantial theory of sound will appear to our reason as not only consistent with observed facts, explanatory of sound phenomena, but rational in every sense.

In the first place, the philosophy of substantialism regards the forces of nature as objective entities, as real, substantial things, and different forms or manifestations of the all-pervading force-element of nature, which is an immaterial substance, and which is constantly put forth and sustained by the infinite. Second, the word substance is a generic term, and embraces material as well as immaterial substances—all matter being substance, but all substance not necessarily material.

All material substance is supposed to have been synthetized or condensed in different degrees of concentration out of the all-pervading immaterial substance by the Infinite Power, and held together by the substantial force of cohesion.

Just, then, as we see a graduated ascending scale in material substances from osmium, the heaviest of all metals, through lithium, the lightest of all metals, through acetylene, the lightest of all liquids, through hydrogen, the lightest of all gases, through odor, the most highly attenuated condition of all material substance, so, on the other side, commencing where the material left off, and ascending from odor, we have the substantial force of cohesion, chemism, adhesion, heat, sound, electricity, magnetism, gravitation, light, soul, mind, and spirit.

An *immaterial substance* must necessarily be such an entity as does not possess the recognized properties of weight, inertia, physical tangibility, etc., and which can operate and exist in defiance of purely material conditions.

We are compelled to judge of the substantial or entitative nature of anything of which the mind can form a concept, not by its recognizable or unrecognizable qualities through the direct evidences of our finite senses, but by its demonstrable effects upon other and known substances under the exercise of our rational faculties in judging, analyzing, comparing, what they accomplish.

To assume *force* to be insubstantial or a non-entity is to attempt to conceive of the most manifest and gigantic physical effects as without a cause, such, for example, as the shivering of a forest tree to splinters by a touch of electricity, or even the pulling of a satellite or planet from its tangential course by an invisible and intangible mode of motion called gravity. Motion surely is not force, it is a phenomenon, the result of the application of force to a body; withdraw the force, and motion is at an end.

Because a force cannot be seen, heard, felt, tasted, or smelt is no proof that it is not an objective thing, an immaterial substance, as really and truly as water is a material substance; on the contrary, by its action and what it accomplishes, we are compelled to give it an entitative existence, especially as science has shown that, like matter, force can change its former manifestation, but cannot be annihilated, its quantity cannot be altered; it must therefore be an entity, and, if an entity, must be an immaterial substance, as it defies material conditions.

Magnetism, that can lift a hundred or more pounds of iron against the attraction of gravitation, can only be known to exist by its observed effects, not upon our sensations, but upon inanimate objects. The same is true of gravity.

The same also would be true of light, were there no eyes, and of odor, but for the single sense of smell, no possible experiment within human reach enabling us to prove its existence except by that sense alone. How many other real substantial entities, with wonderful properties and powers, may exist in surrounding nature, but wholly intangible to any of our senses, it is impossible for us even to imagine. With this brief insight into the nature of matter and force, we can readily imagine the vast and far-reaching scope of the substantial philosophy.

Sound, therefore, according to the substantial philosophy, is a substantial force, one form of the force element of nature.

As all the forces of nature are mutually convertible into one another and back into the force element itself, so substantial sound force can be converted into substantial heat, electricity, etc., as substantial heat and electricity can be converted into sound. 3. Force acts upon force in changing from one form of manifestation to another, and no force dissappears to reappear into any other form until it has accomplished its work; in other words, a force never loses its identity until it has expended all its energy as such.

The truth of this statement is witnessed in the acoustical telephone, over which sound can be heard for a distance of only a few miles. The substantial sound force finds much difficulty in passing through the wire, as it has to contend with the substantial force of cohesion, which in turn is controlled to a certain extent by the substantial forces of heat and electricity present in the wire under normal conditions—the result is that by degrees the substantial sound force is converted into heat during its passage, until it disappears as sound altogether. It succeeds, however, much better in traveling through the wire than it would through the air, only, however, because the wire is a better conductor, *i. e.*, offers less resistance to its passage. The substantial forces at work in the air so control its passage through it as to permit it to travel at a velocity of only 1,093 feet a second, while iron wire permits it to travel through it at a velocity of over 17,000 feet a second.

As a force will always travel in the direction of the least resistance, it would be expected that a wire would pick up from the air the various sounds traveling through it, and thus produce a rumbling noise in the phones, which actually does take place, especially in the phones used in large cities.

4th. All material bodies as we know and handle them contain, as stated, substantial cohesive force, substantial heat force, and substantial electrical force.

The *truly normal* condition of all material bodies, as pointed out by Dr. Hall, is the solid deprived of substantial heat—they would then be at *absolute* zero potential as regards this force. We cannot, however, deal with any bodies at absolute zero potential as regards either heat or electricity. And it is for this reason that a force has work to do in passing through a material body. If a piece of silver from which sufficient heat has been taken to reduce its temperature to 32° F. be tested, it will be found that substantial electrical force will pass through it with far less resistance (*i. e.*, having less work to do) than if the silver be allowed to take up sufficient substantial heat force to raise its temperature to 212° F. If we represent its conductivity at 32° F. as 100, at 212° F. its conductibility will be reduced to 71·316.

5th. To detect the presence of the substantial force of electricity in a body at zero potential (not *absolute zero*) it is necessary that some body in its vicinity be placed in an abnormal condition. Then, as electricity repels electricity, there is a difference of potential which exists until an equilibrum is established.

To illustrate this—we may assume, that a given metallic and insulated cylinder in a room is at zero potential, that is, there is to observable difference of potential between the electrical condition of the cylinder and the electrical condition of other objects in the room or the room itself. Now, bring into the room in the vicinity of this cylinder a cylinder charged with + potential or electricity (which is naturally in an abnormal condition to the things in the room). Then, since electricity repels electricity, there will be found a difference of potential in the first cylinder—the opposite end to the charged cylinder being at + potential and the near end being at — potential, and this state of affairs will exist until the charged body parts with its excess of electricity to the first cylinder and surrounding bodies in the room, and the room itself is at zero potential again. This change in the electrical or potential condition of bodies has been attributed to induced electricity, when it is plainly due to a disturbance in the electricity present in all bodies, by the presence of a body at a higher potential. With this explanation, it is not difficult to explain why sound travels further over the secondary circuit of an electrical telephone than over the circuit of an acoustical telephone. It results from the fact that the primary circuit is at a + potential as regards the potential of the secondary circuit, hence the potential or electrical condition of the secondary circuit is disturbed, which disturbance favors the passage of the substantial sound force (*i. e.*, the other substantial forces, cohesion, heat, etc., not offering the same resistance as when the electrical condition of the wire is unchanged); it therefore travels with greater velocity and to a much further distance, but in time, as it always has to work its way, it is converted into heat, or some other form of force manifestation, which takes place after it has traveled some few hundred miles. Just as sound force, which emanates when we whisper to one another in a room, can only affect us at a certain defined distance depending somewhat on the sensitiveness of our organ of hearing to be impressed, but more on the fact that the sound force, having work to do, is partially converted into heat before it reaches us, so is there a well defined limit to the distance that sound force which emanates from loud speech can affect us, either traveling through the air or through an acoustical or electrical telephone.

I have stated above, that experiment has shown that for the human ear to be impressed by a sound it must receive at least 16 pulse effects in one second; something more than this is necessary, as the number of pulse effects in one second simply determines the pitch of a sound, not the intensity, which is alone dependent upon the blow or pulse effect that any particular sound is capable of giving after traveling through a medium. A rabbit or hare can hear sounds that we cannot hear, *i. e.*, their organs of hearing can be impressed by a weaker pulse than the human organs of hearing, and probably by sounds whose pitch is much lower than 16 pulse effects per second.

Right here, I will state that just as electricity is generated by lifting a weight, by separating two pieces of paper, by the conversion of the substantial attractive force of adhesion or cohesion, as the case may be, so also is sound produced of greater or less intensity—but having in the case of the weight generally too low a pitch (*i. e.*, too few pulses in one second) or too weak an intensity to affect our organs of hearing; while among some animals, if the intensity was sufficient, the pitch would possibly be quite high enough to affect their organs of hearing.

The fallacy of the wave theory of sound has been clearly set forth in the columns of the *Microcosm*, as also in my work on the subject, so it will be unnecessary to go into an exposition of the arguments and experiments used to annihilate it. Suffice it to say that numerous institutions of learning in this country have abandoned the same as perfectly unworthy of further countenance. One expression of opinion in relation to the wave theory of sound is all I will give, and is from the pen of Prof. C. H. Kiracofe, President of Hartsville University of Indiana, who says: "We no longer teach the wave theory of sound as science, but as a theory worthy of consideration only as an example of what may be palmed off on the world as true science."

We will therefore proceed with the consideration of the substantial theory of sound.

When a tuning fork is struck, or made to vibrate by other means, at each vibration a pulse of sound force is sent off which travels at 0° C. at the rate of 1,093 feet in one second through the air.

Just as substantial electrical force requires a conductor for its transference, so does substantial sound force. The rate of transference depending upon the resistance offered to its passage, hence we have good and poor conductors of sound. There being no air or other conductor in a vacuum, naturally we do not hear sound, and in this case the energy which would have been converted into sound is converted into some other form of substantial force manifestation, probably heat.

The energy, that is to say the power of doing work, a tuning fork possesses after being struck or bowed is stored up substantial force, which is partly converted into substantial heat in the tuning fork while vibrating, and part sent off in pulses of sound at each swing of the fork, so naturally, as this stored up force or energy is continually being diminished, the pitch of the sound produced, while never varying, still varies in intensity, and can be heard loud at the start, at a given distance from the fork, and then less loud and so on, until the substantial sound force is converted into heat and disappears, as less sound force is produced as the amplitude of swing of the prongs of the fork diminishes, hence it can only travel a less distance, as it has work to do in traveling through the air or other medium as conductors.

The frequency of the prong (*i. e.*, its number of vibrations) in one second never varies in number, but does vary in the width or amplitude of swing, the number of vibrations determining the pitch, while the amplitude of swing the intensity, which depends upon the amount of stored up substantial force or energy that has been imparted to the fork.

It is clear, therefore, from what has been said, that sound is not transmitted by condensations and rarefactions of the air, in wave or undulatory motion, but that sound is a substantial force which is sent off as the energy of a vibrating body is converted into the same; and if the frequency of the pulses of sound force are at least 16 in one second, and of sufficient energy, our organs of hearing will be impressed, and we will become conscious of hearing the sound thus produced, while, on the other hand, if the frequency of the pulses are more than 40,000 in one second, or even if less frequent, but not possessing sufficient energy to affect our organs of hearing, we will not become conscious of the sound, while some animals, who have ears more sensitively constructed, may be able to hear sounds which have a very long pitch and low intensity, or high pitch with low or even high intensity, as before intimated.

Conversation, therefore, for aught we know, may be carried on between animals by sounds whose pitch and intensity pass by us unnoticed.

As some confusion may arise from the adoption of the word pulse, it may be well to draw a distinction between the use of the word by the wave theory of sound and the use which is adopted by the substantial theory of sound.

If a series of ivory balls be placed in a row, and the

first one hit, a pulse is said to travel through the balls and cause the last ball to fly off. This is the use given to the term by the wave theory; while according to the substantial theory, *a pulse* is an emission of sound force, caused by one stroke or vibration of a body; and just as often as the vibration takes place, just so often will a pulse of sound force be sent off. So that a tuning fork making 256 vibrations in a second will send off 256 pulses of sound in one second, and the distance to which the pulse will travel will depend upon its energy (*i. e.*, its power of overcoming the resistance offered by the substantial forces present in the medium through which it travels). The amount of energy that is converted in its production will determine, therefore, the amount of energy the sound pulse will have.

It is easy from this explanation to understand why it is that a stretched membrane is made to vibrate, when sounds are directed against it. The pulse of sound force strikes the membrane in its endeavor to pass through it, and owing to the resistance offered by the substantial force of cohesion in the membrane and other substantial forces present, the membrane is made to tremor or vibrate, which vibration is assisted by the succeeding pulses of sound force until the sound ceases and the membrane finally comes to a state of rest.

The tremor or vibration of the membrane is a forced condition, and while capable of producing sound pulses itself of low intensity, still the vibration is entirely incidental to the passage of the original sound, as any motion imparted to the air by its own vibration or the original body producing the sound is incidental to the production of sound, and is not sound itself.

It may also be well to state that, according to the philosophy of substantialism, matter is considered homogeneous and not heterogeneous, and consequently is devoid of molecules and atoms; and in three elaborate papers on the question, "*Is matter heterogeneous or homogeneous?*" which have appeared in the *Microcosm*, I have replied to each argument advanced by the physicist and chemist by the light of the new philosophy, and such arguments have been found wanting in validity.

If, therefore, matter be homogeneous, although more or less porous, the wave theory of sound, which depends upon the harmonic motion of the molecules, and their crowding nearer together in the condensation and their spreading more widely apart in the rarefaction, has no foundation in fact, as matter is not composed of molecules at all.

Experiment and reason dictate that matter is theoretically infinitely divisible; of course it must be conceded that a finate ability could not disintegrate matter to infinity. This alone can be accomplished by the Infinite. The state in which matter would be when divided to infinity is what confuses the mind, as it will always confuse the finite to understand the Infinite.

The one and only great and incomprehensible problem in this world, which can never be fathomed or elucidated by the finite mind, is that of the Infinite.

Here science must veil her face and bow in reverence before its all-pervading majesty.

The siren, which is familiar to all scientists, is an instrument which is capable of producing different pitches of sound of great or less intensity, by forcing air through orifices in a revolving disk.

The double siren is simply a duplicate of the single siren.

Given 12 orifices in each disk, then, by operating the two sirens together, so that the 12 puffs of the upper siren alternate with the 12 puffs of the lower siren, 24 puffs will be obtained, the same as if the revolving disk contained 24 orifices instead of one, the result of which will be the production of the octave, as we double the number of puffs which cause the fundamental tone or the pitch produced by one disk acting alone. If, on the other hand, we produce a tone consisting of 12 double unison puffs, they naturally re-enforce one another, and the intensity is increased fourfold, but the pitch is not raised.

By rapidly revolving the disks, any number of puffs can be made per second, which number will determine the pitch of the tone.

The energy of each puff is in part converted into a substantial sound pulse, and as the energy thus converted may be great, the intensity of the sound will likewise be great, and consequently can be heard from a steam siren for over ten miles; the pitch depending alone on the number of pulses per second, or, in other words, the number of puffs which produce a like number of sound pulses.

To determine the exact pitch of a note, the siren is unquestionably of value.

It is not difficult to understand, according to the substantial theory of sound, why it is that by using a funnel or an ear trumpet the intensity of sound is augmented. Sound force at the moment of generation travels in all directions; consequently, if a funnel is used, more sound force will be directed against the organ of hearing than if it were not collected and thus focused; the number of pulses will not be changed, but their energy will be intensified, and consequently the sound will be heard more distinctly.

From actual experiment conducted by Capt. Carter, he found that instead of sound diminishing as the square of the distance, instead of four equaling one at double distance, four equals one at thirty times the distance. In the vicinity of a sound-producing body (take a piano, for example), the pulses of sound force are sent off with great intensity, possessing considerable energy, but as the organs of hearing are small, only a given quantity of substantial sound force can enter the ear from each pulse, and consequently the sound is not of deafening intensity. As we recede from the instrument, the same number of pulses per second strike our organs of hearing, but the energy of sound pulse is more or less spent in overcoming the resistance offered by the substantial forces present in the air, and if we recede far enough away, we no longer are conscious of sound.

In a room the walls reflect or throw back the sound pulse, and consequently there is no observable difference in the intensity if the room be not too large. In a large hall, however, the difference in the intensity is quite observable.

The effect of a substantial sound pulse is witnessed in the sympathetic vibration of unison tuning forks.

If a tuning fork is caused to vibrate, at each vibration a pulse of sound force is sent off, which travels in all directions; and if a unison fork be in the vicinity, the prongs of the unison fork will be struck by each sound pulse, and in a short time, if the two forks are in perfect unison (*i. e.*, vibrate exactly the same number of times in a second), the unison fork will start to vibrating by the stored up energy derived from the substantial sound pulse which strikes it on its advancing journey. Is it possible to explain the vibration of any body whatever except by the application of the energy of a substantial force? Surely the explanation here given to the sympathetic vibration of tuning forks in perfect unison would have been deduced from reasoning if the experiment had never been conducted and the fact of sympathetic vibration verified.

It being understood that a tuning fork of a given number of vibrations per second never changes the number until it comes to rest, the only change which actually takes place is the width of swing or amplitude of stroke as the stored up energy disappears. Hence a tuning fork can only be set in vibration by the substantial sound force sent off by another fork which has identically the same number of vibrations per second.

The organs by which human speech is produced are* the lungs, the larynx, and the parts of the mouth above the larynx. The lungs are, as it were, the bellows of the organ; they simply produce a current of air, passing out through the throat, and vary in rapidity or force according to the requirements of the speaker. The larynx is a kind of box at the upper end of the windpipe, and contains what is equivalent to the reed of the organ pipe, with the muscular apparatus for its adjustment. From the sides of the box, namely, spring forth a pair of half valves, of which the membraneous edges, the "vocal chords," are capable of being brought close together in the middle of the passage, and made tense, so that the passing current of air sets them in vibration, and this vibration sends off pulses of substantial sound force, which, on reaching our organs of hearing, make us conscious of the words spoken.

In ordinary breathing, the valves are relaxed and retracted, leaving a wide and rudely triangular opening for the passage of air. Thus the larynx gives the element of tone accompanied with variety of pitch. From this explanation it is evident that speech ought to be transmitted telephonically in a suitably constructed electrical instrument, by taking advantage of the ability the individual pulses necessary for each word spoken ought to have, when directed against a diaphragm, to vary the resistance as well as to open and close the primary circuit associated with the secondary circuit. Just this thing has been accomplished by Prof. James W. Bouta, of Philadelphia, and for which he has received a patent, and which result is contrary to the wave theory of sound, and, therefore, inexplicable by such theory, as many prominent scientists who have examined the same have had to admit.

The Bell telephone operating in a closed circuit, and the sounds supposed to be transmitted by an undulatory motion of induced electricity in the secondary circuit, and finally converted into sound by the final vibrations of a diaphragm.

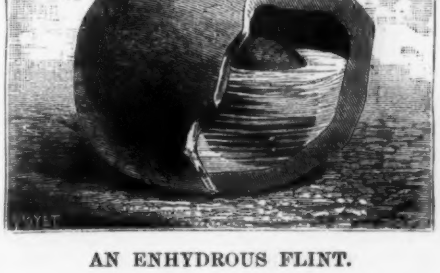
This new telephone, which is only explainable by the substantial theory of sound, will be the subject of another paper.

I will only state here that sound is not converted into electrical undulations and then back again into sound, but the substantial sound force advances as sound force until it is converted into some other form of force manifestation, and never loses its identity until so converted, when as sound it ceases to exist.

This may be before the sound reaches the ear, provided the ear is several hundred miles away, or if the ear is sufficiently near, and the energy of the sound pulses is still great enough, the sound pulse on striking the ear will make us conscious of the communication.

A FLINT CONTAINING WATER.

WE owe to the courtesy of Mr. Doigneau, of Nemours, a small specimen which appears to be thus far without analogy in geological collections. It is a nearly spheroidal flint stone, which is about one and three quarter inch in diameter, and which, in addition to a stony nucleus, contains a notable quantity of water, as well shown by the noise that it makes when the stone is shaken.



AN ENHYDROUS FLINT.

Our readers are already acquainted with the enhydrous, quartzose concretions that are derived from amygdaloidal rocks; and their origin is well known. The silica, deposited layer by layer in the cavities of the evaporative mass, has of itself in certain cases obstructed the channel that gave passage to the mineralized water, and the latter has thereby become imprisoned in varying quantity, and has, usually along with air, remained within the stony and transparent sphere. We do not know that any one has ever pointed out the same peculiarities in flint stones, although they may be explained in an analogous manner, since, like agate, flint is the result of successive deposits within a previously formed rock.

The Nemours specimen was collected, not in place, that is to say, not in the chalk in which it was formed, but in the Quaternary gravels of the valley of the Loing, where it has remained among the residua of the secular denudation of the secondary strata.

As regards the nature of the water inclosed, the idea that first occurs is that the liquid may constitute a specimen of the very ocean on whose bottom was deposited the sediment in which the flint was *in situ*. But, aside from the fact that observations show that flint-stones are of an age posterior to that of chalk, and that they are even (at least in part) now in course of formation in calcareous masses, it must be remembered that silicious matter is far from being impermeable. As well known, the enhydrous quartz stones that are preserved in collections soon lose their water through their porosity, and it is possible to impregnate agates with honey water, sulphuric acid, etc. It must evidently be the same with the Nemours flint. So it would seem proper to look for the cause of the existence of water in the stone under consideration in the conditions of the Quaternary bed. The stone exhibits no visible fissure, even under a strong lens; but we doubt not that its unusual features might be imitated by submitting to sufficient pressure certain hollow flints of the diluvium that had previously been immersed in water.

LAGGING SUBSIDENCE VS. ELEVATION IN PHYSIOGRAPHICAL GEOLOGY.

By JAMES RICHARDSON.

FEW ideas play a larger part in physiographical geology than those involved in such terms as *upheaval, mountain elevation, continental uplift*, and the like.

The geological record, as now interpreted, is, in fact, little more than a long history of alternating subsidences and continental upliftings, interspersed with periods of real or relative quiescence.

Taken as a whole, the dry land of the earth owes its existence to upheavals, Professor Geikie tells us in his Text-Book of Geology (p. 911); and every other authority on the subject teaches the same doctrine with more or less precision of statement.

No adequate cause has been assigned for the present distribution of the land, the same writer observes in another connection; but whatever that cause may be, it must have begun to operate very early in the earth's history.

"There is reason to believe, indeed, that the present terrestrial areas have, on the whole, been land, or at least have never been submerged beneath deep water from the times of the earliest stratified formations; on the other hand, the ocean basins have always been vast areas of depression." (P. 35.)

Similarly, Professor Dana observes that "the continents and oceans had their general outline or form defined in the earliest ages." (Manual, p. 732.)

Since the sub-aerial wear and tear of the continents is sufficient to reduce them to the sea-level in a comparatively brief period, geologically speaking, and since the land erosion going on to-day is relatively slight, it is clear that the aggregate erosion during all the ages must have been many multiples of the present height of the highest lands. Accordingly, if the present continents are due to upliftings of the earth's crust, such upliftings must have been, as indeed all geologists teach, very many times repeated, and on the most gigantic scale.

Conclusive proofs (so-called) of such upliftings are everywhere found in the stratified rocks, the more recent formations being largely made up from the waste of older formations. "This could not have happened but for repeated uplifts, whereby the sedimentary accumulations of the sea-floor were brought within reach of the denuding agents. (Geikie, Text-Book, p. 911.)

I have failed to meet with any geological authority who does not present substantially the same view. It is only when an attempt is made to discover the source of the titanic forces which are credited with thus maintaining the integrity of the continents that any great difference of opinion arises. Yet, however much they may differ as to details, recent investigators of this problem are generally inclined to follow in the main the lead of Mallet in seeking the uplifting power required in the squeeze put upon the earth's outer layers by the radial contraction of the planet in consequence of loss of heat. According to this view, the hotter nucleus contracts more rapidly than the cooler and more hardened crust, and the outer shell, in sinking by gravity, has to accommodate itself to a constantly diminishing diameter; in other words, it must squeeze itself into a narrower area, thus putting upon the sinking strata such a lateral pressure as to produce aqueous fusion, with volcanic outpourings in some places, in others rupturing the overstrained strata, producing mountain ridges, or else bending the strata upward into continental undulations.

Professor Dana summarizes very cogently the lines of evidence pointing to this, to him, very satisfactory conclusion. Professor Geikie presents the same view, in the main approvingly, with great wealth of illustration and argument. He is forced to admit, however, that "no altogether satisfactory solution of the problem has been given, and that the subject is still beset with many difficulties."

To escape such difficulties, some authorities, among them Professors Le Conte and Shaler, have suggested the existence of a liquid or viscous stratum between the outer solid crust of the earth and a more or less solid nucleus; the contraction and consolidation of such interstratum giving rise to the corrugations of the surface.

Mr. Fisher takes the same position in his "Physics of the Earth's Crust." In his more recent treatise on geology, Prof. Le Conte lays especial stress on the conditions producing slaty cleavage in explaining mountain uplifts; but the forces involved would seem to be too limited in range of action to account for the uplifting of vast continental areas, with such uniformity of movement as to displace the superficial strata thousands of feet vertically without disturbing their horizontal trend, except locally and in relatively narrow areas.

It would require more assurance than the writer possesses to pretend to settle questions which baffle the ablest investigators. Nevertheless, he may claim the privilege of doubting, with them, the sufficiency of the current explanation, and of hazarding the suspicion that the worst of the difficulties encountered in this connection may have arisen, not from any necessity of the case, but from a conventional misreading of the

* See Life and Growth of Language, p. 59, Whitney.

testimony of the rocks. It may be that the supposed upheavals never occurred, and consequently do not call for explanation.

The fact that marine strata lie thousands of feet above the sea may be, as is commonly held, a conclusive proof that such strata have been lifted up. That there has been a displacement is evident; but it is quite possible that geologists are mistaken in inferring in all cases an upward movement of the land.

Similarly, the fact that originally horizontal strata now lie tilted against the slopes of mountain ranges may be proof that the mountain cores have been thrust upward by forces acting from below. But the observed facts are susceptible of a very different and perhaps equally satisfactory explanation. And so with other accepted proofs of terrestrial upheaval.

A pretty illustration of similar appearances, plainly traceable to very dissimilar conditions (as the geological conditions are interpreted), may be seen any day in winter, where ice formed at high water is subjected to strains and fractures through the subsidence of the water and the more or less complete arrest of the sinking ice locally by rocks and other resisting materials. At such times the larger inequalities of the earth's surface, isolated mountains, mountain ranges, plateaus, plains, and the rest, are curiously and instructively imitated by the more or less disturbed and distorted ice sheet.

Seen at low water, the ice looks as though it had been pierced from below by rising banks and rocks, and the first natural impression is that the movement of the ice has been most where the visible disturbance is greatest, when in fact the ice where it is most fractured and tilted has been less displaced vertically than where it lies level, unbroken, and apparently undisturbed.

It is at least possible that the parallel may hold good with the rocky strata; that in making their observations after the event, geologists have simply misinterpreted appearances. If so, the most perplexing problem of dynamical geology is not solved, but eliminated. If intermittent subsidence will suffice to produce the conditions observed, it ceases to be necessary to account for continental upheavals, which may never have occurred.

Whether we regard the land areas as uplifts, as commonly held, or as halting or lagging areas in a general subsidence, as here suggested, terrestrial shrinkage is assumed to be the primary cause of all geological displacements. The evidence upon which physical investigators base the belief that the earth is shrinking does not concern us here. Accepting such shrinkage as a fundamental fact, the object of this paper is simply to raise the question whether shrinkage alone, with the consequent radial contraction, unattended by the frequent and enormous reversals of the general downward movement which geologists assume, may not suffice to account for the facts of observation.

How much the earth has contracted during the geological ages it would be hard to say. Mallet calculates that the present diameter of the earth is not less than 189 miles less than it was when the planet began to solidify. In other words, its original crust was something like a hundred miles higher—further from the earth's center—than the present surface is. If any considerable fraction of this shrinkage has taken place since the beginning of the geological record, and there is no reason to doubt it, there would be provided ample vertical space for all existing and antecedent inequalities of surface level; and if any portions of the surface have cooled and subsided less rapidly than other portions, the lagging areas would become high lands as a matter of course, though always sinking and never elevated.

Let us see what geology and physical geography have to say on this point.

In his chapter on dynamical geology, Prof. Geikie lays down a number of fundamental facts, which he says must be taken into account in every attempt to explain the earth's dynamic history, namely, that "the large terrestrial features, such as the great ocean basins, the lines of submarine ridge, the continental masses, and at least the cores of most great mountain chains, are in the main of high antiquity, stamped, as it were, from the earliest geological ages on the physiognomy of the globe."

Accordingly, if the hypothesis of differential shrinkage is sound, it must be able to show how these great terrestrial features have maintained their integrity through such incalculable periods; how and why the sea basins have kept ahead of the continents in the general subsidence, despite the fact that they have in part received, while the land surfaces have lost, eroded materials that can be measured only in vertical miles.

Since loss of heat is, as all authorities hold, the chief cause of the earth's contraction; and since the ocean basins have subsided more rapidly or continuously than the continents, we must infer that from the earliest rock-recorded ages the sea beds must have been in a condition to carry away or permit the carrying away of the earth's internal heat more rapidly than land areas of corresponding latitude, and since contraction implies increase of density, the sea basins ought to possess to-day an excess of specific gravity as compared with the continents.

On the first point we have the evidence furnished by recent deep sea explorations, which have disclosed the remarkable fact that, under the surface layer of ocean water affected by the temperature of the latitude, there lies a vast mass of cold water, the bottom temperature of every ocean in free communication with the polar seas being icy cold. The ocean waters, as a whole, are everywhere colder than the normal temperature of each latitude; much colder, it is said, than the superficial parts of the earth's crust beneath. The sea bottoms are colder than the corresponding land areas, yet not so cold as the overlying water.

This being the case, the bottom drift of icy water toward the equator must everywhere be abstracting heat from the strata underlying the seas much more rapidly than the earth radiates heat from the warmer land surfaces. And as the oceans have been substantially where they are since the earliest geological times, this relatively excessive loss of heat must have characterized the ocean beds through all the ages, and, as a matter of course, their subsidence must have been correspondingly excessive. The present well known, but hitherto unaccountable, deflection of the plumb-line seaward is certainly not inconsistent with the state of things thus indicated.

In his treatise on the figure of the earth, Archdeacon Pratt asserts that such plumb-line observations indicate that the density of the earth's crust, under mountains, is less than that below the plains, and still less than that below the oceans; from which fact I should infer, not that the mountains are cavernous or hollow, as some geologists have imagined, or that they have been squeezed up under enormous lateral compression, but simply that the contraction and consolidation of the part of the earth's crust under them has gone on less rapidly or continuously than has obtained under the seas.

Pendulum observations in various parts of the earth point to the same conclusion.

At the meeting of the British Association last year, General J. T. Walker, formerly chief officer of the great trigonometrical survey of India, in his address as President of the Geographical Section, discussed at considerable length the results of the pendulum observations made for that survey. These observations, he said, revealed two broad facts regarding the invisible matter below the earth's surface: "First, that the force of gravity diminishes as the mountains are approached, and is much less on the highly elevated Himalayan table lands than can be accounted for otherwise than by a deficiency of matter below; secondly, that it increases as the ocean is approached, and is greater on islands than can be accounted for otherwise than by an excess of matter below." Again, he said:

"The hypothesis of sub-continental attenuation and sub-oceanic condensation of matter is supported by two arcs of longitude on the parallels of Madras and Bombay; for at the extreme points of these arcs, which are situated on opposite coast lines, the horizontal attraction has been found to be, not landward, but seaward, showing that the deficient density of the sea (water), as compared with the land, is more than compensated by the greater density of the matter under the ocean than under the land."

The deficient gravity of the Himalayan mountain region was such that a pendulum which beat seconds at the sea-shore lost, at an elevation of 15,400 feet (in excess of the normal loss due to height above the sea), as many as 22 beats a day. On the coast islands the gain was three seconds a day. Equally instructive results were obtained by Prof. Mendenhall (Memoirs Scien. Dept. Univ. of Tokio), in the Japanese Islands. At Tokio the seconds pendulum gained 1·3 beats a day; at the northern and southern extremities of the islands the gain was over three seconds. At the Bonin Islands, well out in the Pacific, the gain was 14·9 seconds. At Ualan, one of the most southeastern of the Caroline Islands, Capt. Leutke reported a still higher rate of gain. Similar results were obtained by our late astronomical expedition to those islands, all indicating that, notwithstanding the surrounding depth of relatively light sea water, the specific gravity of the earth out at sea is considerably above that of the continents.

The existence of such a vast sheet of water as the Pacific Ocean, Archdeacon Pratt observes, is to be accounted for only by the presence of some excess of matter in the solid parts of the crust between the ocean and the earth's center. Similarly, the fact that the southern hemisphere is almost wholly covered with water appears to Prof. Geikie to be explicable only on the assumption of an excess of density in the mass of that half of the planet, from some accident of original constitution or for some other reason not known.

What "accident of original constitution" shaped the earth's original surface so as to turn the primeval seas into their present basins it is too late now to inquire; but, once established, the oceans must of necessity have preserved and deepened their basins, and this process of excessive cooling and contraction may help to account for the present greater density of their underlying strata.

In summing up the dynamic history of the globe, Prof. Geikie says: "From the earliest times the existing continental regions seem to have specially suffered from the efforts of the planet to adjust its external form to its diminishing diameter and its lessening rapidity of rotation. They have served as lines of relief from the strain of compression during many successive epochs. It is along their axial lines, their long dominant mountain ranges, that we should naturally look for evidences of corrugation. Away from these lines of weakness the ground has been upraised for thousands of square miles without plication of the rocks, as in the instructive regions of the western territory of North America. Nor is there any sign that corrugation takes place beneath the great oceanic areas of subsidence."

The strata of all the great plains—like those of Russia—seem to have been similarly exempt from lines of weakness, for they have equally escaped corrugation, notwithstanding the vast and repeated upliftings they must have undergone, if the current theory is correct.

Continental axes are to be regarded as lines of weakness in the earth's crust, I suppose, for the same reason that we would call a reef of rock underlying and partly supporting a subsiding ice sheet a line of weakness; both are apt to be marked by tiltings, fractures, and similar disturbances of the adjacent "crust."

It must not be inferred that, in laying special stress upon lagging subsidence as opposed to elevations in the determination of continental areas, there is any disposition to deny the minor local flexures and upheavals which attend mountain formations. That is an entirely different field of inquiry, though involved in the larger field. The same may be said of the minor oscillations of the sea level, for well known causes, the shifting of ice accumulations at the poles, and the like-producing submergences and emergences of the land within a limited vertical range, irrespective of any actual movement of the land.

The curious and hitherto inexplicable geological see-saw, which results in the apparent depression of areas of great surface wear and a relative elevation of areas receiving the abraded materials, ancient estuaries and the great lake beds of the earlier geological ages, converting such areas into lofty plateaus to be carved perhaps into mountain clusters, is, under the new hypothesis, not quite so puzzling as before. That areas specially loaded by great deposits should rise in consequence of such loading, as geologists teach, is a paradox of the largest sort. That such areas should sink less rapidly for such loading seems scarcely less paradoxical, until we consider that, in the general subsidence through loss of heat by radiation into space, it must make a great difference in the heat transmitting capacity of two adjacent regions to take from the one a protecting (earth) blanket, perhaps miles in thickness, and apply it to the other. This, independent of any thermal effects incident to increased pressure on the strata underlying the new deposits, and the relief of pressure on those under the region of erosion, since the land waste carried down to the sea by rivers does not go far to sea, and since the more rapid deposits of shell-life and coral builders are for the most part similarly restricted, we may infer that the deep sea basins must continue to subside most rapidly under the influence of secular cooling and contraction, the seas growing deeper and the continents broader, allowance being made for the oscillations of sea level already referred to, and their effects on coast lines. Next in order of subsidence will be the wasting continents, especially their great plains. The tendency of the sea margins and the great river-receiving bays and estuaries must be to lag, more especially after the deposits thereon have become thick enough to reduce to the minimum their capacity to transmit heat from the warmer nucleus or substratum below.

Given time enough, such lagging or entirely arrested subsidence must manifest itself in an apparent upward movement, the adjacent regions and the sea level itself going down with the general subsidence of the earth's surface; but the situation is such that lateral thrusts from the more rapidly subsiding areas, and a corresponding rise in temperature with metamorphic action, would probably unite to give such local areas an actual movement upward, in addition to its relative gain in elevation.

If this view of the larger geological displacements proves tenable, some material changes must be made in geological theories.

Continental areas will be attributed, not to elevations of the earth's crust by tremendous forces acting from below, but to a smaller movement downward than the seas have made.

The high lands of the earth—plateaus and the like—will be considered, not as marking regions of greatest displacement upward, but of least displacement downward.

The larger disturbance of the rocky strata along continental axes will be attributed, not to up-thrusting mountain cores, but to an upholding of the adjacent strata against surrounding subsidence.

The great lines of elevation and fracture of the earth's crust may be considered as marking, not lines of weakness, but lines of superior stiffness and resistance to the general subsidence, through the earth's radial contraction.

The great problem of geological dynamics, the search for a force capable of lifting continents, bodily and without tilting, thousands of feet, will be given over as uncalled for and idle.

The terms *upheaval*, *uplift*, *epochs of elevation*, and the rest will play a less prominent and more appropriate part, as naming secondary, not primary, factors in geology.

ON THE ENRICHMENT OF COAL GAS BY CERTAIN HYDROCARBONS.*

By GEORGE E. DAVIS, F.I.C., F.C.S.

EVER since the introduction of illumination by means of coal gas, various processes having for their object the enrichment of the gas with certain hydrocarbons have been put forward and patented. One by one have these processes appeared, and as certainly have they disappeared, so that there remains but the bare record of their existence; and, strange to say, there does not appear, in the literature devoted to the subject, any rational ideas of the "why and wherefore" of the failures of the different processes which have from time to time been devised. If we go back to the earliest records of gas lighting, we shall find that the tar produced in the operation of the manufacture of gas proved in those days to be an article very difficult of sale; and many efforts of a crude nature were made to turn it into gas. In a pamphlet published by Mr. Clegg in 1820, a circular oven was described for carbonizing coal, in which there was fixed (near to the mouth of the oven) a pipe so contrived that the tar as it was condensed returned upon trays, and was thereupon converted into gas. Mr. John Grafton (a pupil of Mr. Clegg) about this time also sought to convert the tar into gas; and in one of his patented settings the retorts were placed in an inclined position, and a secondary retort added for the purpose of receiving the tar and converting it into gas. This idea was never probably worked out with a view of enriching ordinary coal gas, but was most likely adopted as a means of getting rid of a very noxious and inconvenient by-product, for in those days the expedient of utilizing it as a fuel was not thought of.

Supposing for a moment that these crude attempts, and others of a similar nature which followed them, had been successful in the matter of gas making pure and simple, it is doubtful how far they would have conduced to the enrichment of the gas; as I have found by experiment that the pitch, which constitutes about three-fifths of the total weight of the tar, produces a gas absolutely devoid of illuminating power in quantity about 25 per cent. of its weight, and the accumulation of naphthalene and of heavy oils in the process would militate against successful working. At an early date, however, many processes were devised by Ibbetson, Donovan, Selligue, Sanders, Manby, Val Marino, White, and others, having the idea in view to enrich ordinary coal gas with the vapors of certain hydrocarbons, or to impregnate non-illuminating gases with these vapors so that the resulting gas might be used for purposes of illumination. All these processes have sunk into oblivion in this country, for one very good commercial reason, viz., there is no cheaper raw material than coal upon which to operate, nor is there any other substance extant which will give as a basis, by simple destructive distillation, 10,000 cubic feet of gas per ton of coal, of an illuminating power equal to 17 candles, at the same price as coal. In many places, 17 candle illuminating power is all that is required, and when an act of Parliament stipulates for more than this, coal again of a richer quality, in the shape of cannel, is almost universally employed. Any sub-

* A paper read before the London Section of the Society of Chemical Industry, Jan. 4, 1886.

stance, then, for enriching gas must be able to compete financially with cannel coal.

But supposing we are satisfied with the gas (first, I believe, devised by Mr. C. Ibbetson in 1826) produced by passing steam through red-hot coke, the question is whether it is possible to impregnate such a gas with the vapors of volatile liquids more perfectly and more cheaply than can be done during the process of manufacturing ordinary coal gas in the usual manner. I think the able paper of Mr. Lewis T. Wright, read before the Manchester Section of this Society on Dec. 4, 1883, answers this question in the direct negative. Any attempt at the carburation of the gas by employing a compound of the benzene series seems to me the height of absurdity, seeing that it is from coal tar that these products are produced, and the expense of extraction must be added to the original cost of the tar. If these compounds are to be used at all, it is the crude tar which should be operated upon in the gas-works—the tar being made to replace cannel. In 1832, Lowe introduced his system of naphthalizing gas, specially devised for enriching a poor coal gas, in order to make it equal in illuminating power to that produced from cannel coal. The original idea was to use the wet gasmeter as the carbureter, filling it with the light spirit obtained from coal tar; but it was soon found to be too costly, to require too much attention, and to be altogether unsuited for universal application. The principle here advocated by Mr. Lowe has been the favored ground for inventors for many years; but I hope to show the apparent impossibility of its practical attainment, at any rate, under present circumstances.

If, however, inventors have been discouraged by the high and varying prices of volatile members of the benzene series of hydrocarbons, those of the paraffin series (extracted from American petroleum) have been open to them; yet with gasoline at 6½d. per gallon it is very doubtful whether this method would be able to hold its own financially against enrichment by cannel in the usual way. In many places, both for public and private lighting, the system of carbureting gas by impregnating it with the vapors of hydrocarbons has been in use over long periods; and, from the experience gained, it has come to be a recognized fact that, if carbureting is practiced at all, it must either be effected at the burner itself, or if the gas is carbureted at the gas-works it must undergo some special treatment in order to make the illuminants carry to the end of their destination. Carbureting at the burners with liquid hydrocarbons does not, I think, require serious consideration, although I am told it is in operation in the corridors of the Manchester Exchange and also at the St. Pancras Station of the Midland Railway. The replenishing of the reservoir with liquid for each burner would certainly not be practiced for long in any domestic establishment; and for any service of public lighting, the method would not be likely to find favor with the attendants, on account of the extra work it would entail. The liquid used in the two places already cited is good fluid creosote oil; and this at 2d. per gallon is economical.

In order to enable the benzene series of hydrocarbons to be used for carbureting, coal tar would have to be reckoned as of no value whatever; and, indeed, with the present price of 90 per cent. benzol—viz., 1s. 11d. per gallon—it is very certain that many gas-works would do better by using the tar as fuel for heating the retorts, or for carbureting the gas, than by selling it. There are indications now of its being used as fuel in some quarters. Properly applied as a fuel, 1 cwt. of coal tar will do as much work as 2 cwt. of coke; so that there is not much chance of seeing benzol at such a price as will enable it to be used for carbureting.

When a gas is carbureted at the works (as, for instance, in America, where water gas is made on the large scale) the mixture of carbonic oxide and hydrogen, after saturation with the hydrocarbon vapors, is passed through heated retorts, to "fix the carbon," as it is termed, as petroleum spirit is commonly supposed to possess less "carrying power" than the illuminants of ordinary coal gas. There is no doubt that the process of heating does "fix the carbon;" but the reason must be sought in another direction than that usually indicated. The following table shows the vapor tensions of pure benzene and of gasoline; and it would appear therefrom that the latter should have much more carrying power than the former:

Deg. C.	Millimeters of Mercury. Pure Benzene.	Gasolene.
− 10°	13·4	43·5
0°	26·6	81·0
+ 10°	46·6	132·0
20°	76·3	203·0
40°	182·0	301·8

In cases of this kind, however, we must also remember that the nature of the gas itself into which the vapor diffuses exercises a very decided action upon the rate of evaporation. Coal gas is more active than air in the proportion of 1·5 : 1·0; while hydrogen is nearly 3·5 times as active as air. So that, in practice, apparatus for carbureting air would have to be of 3·5 larger capacity than if carbureting a similar volume of hydrogen in a given time.

In order to be in a position to follow the experiments described further on, and to judge of the feasibility of carbureting various gases with the vapors of volatile liquids, it will be as well to cast a glance at the composition of coal gas generally. It must not be supposed that gas from coal possesses any exact composition. The proportions of its constituents are, however, fairly uniform; and it may be taken for granted that, when made from a good quality of ordinary gas coal, it will contain about 46 per cent. of hydrogen and 34 per cent. of methane (marsh gas), with about 8 per cent. of carbonic oxide and small quantities of nitrogen and carbonic acid. This is the vehicle or "carrier;" and is permeated by those vapors of hydrocarbons which give it its illuminating power. These illuminants were generally stated as consisting almost entirely of olefiant gas; and, later, of benzene, propylene, and ethylene. In several recent analyses, the last-named gas is stated to occur to the extent of 2·5 per cent. by volume. Whether or not this is correct, demands further investigation; but I am inclined to think that there is much less ethylene in coal gas than is usually stated, and in some varieties of gas it is doubtful whether it exists at all. With regard to the aromatic series of hydrocarbons, it is certain that these illuminants in coal gas do not consist of benzene simply with a vapor tension equal to that shown in the foregoing table. They consist of the vapors of hydrocarbons boiling below the point of ebullition of pure benzene itself, to that of pseudo cumene and mesitylene, or from 80° C. to 160° C.; and the vapor tension of this mixture of hydrocarbons is far less than that of benzene itself. Ordinary coal gas, therefore, is much more nearly saturated with vapors than most persons imagine.

The vapors of the volatile hydrocarbons present in coal gas may be easily extracted by passing the gas through olive oil; the liquid hydrocarbons being displaced and collected by blowing steam through the saturated oil. It is possible by these means to extract from 3 to 4 gallons of liquid hydrocarbons from 10,000 cubic feet of ordinary coal gas, according to the temperature employed; the illuminating power of the gas being reduced accordingly. In order to ascertain the composition of the vapors made at medium and high temperatures, I passed a large quantity of gas through olive oil, regained the liquid hydrocarbons, and separated them roughly by means of Le Bel and Henniger's fractioning tubes, with the following results:

	Medium Heats.	High Heats.
Hydrocarbons extracted, gallons	4	3·2
Illuminating power of gas before extraction, candles	19	17·0
Illuminating power of gas after extraction, candles	8	8 0
Boiling point of Hydrocarbons.	Per cent.	Per cent.
Below 80° C.	2·0	1·2
80°–83°	53·0	50 1
90°–100°	3·6	2·5
108°–113°	21·0	27·9
116°–128°	3·2	2·1
135°–140°	8·1	11·2
145°–150°	2 0	2·0
150°–160°	3·3	1·7
Above 160°	3·8	1·3
	100 0	100·0

Cannel gas, having an illuminating power of 27 candles, was also passed through olive oil, with the result of obtaining only 2·9 gallons of liquid hydrocarbons; reducing the illuminating power of the gas to 19 candles. This liquid distilled as follows:

	Per cent.
Below 23° C.	12·0
30°– 35°	1·5
35°– 73°	5·2
73°– 78°	11·2
80°– 83°	41·0
85°– 90°	5·0
90°–100°	8·3
100°–108°	4 0
108°–113°	7·1
116°–140°	2·4
140°–160°	0·8
Above 160°	1·5

It will be seen from the above that the nature of the hydrocarbon vapors present in cannel gas is substantially different from those in coal gas. The vapors given off below 23° C. required condensation in ice and salt, and were doubtless those of crotonylene. They were brominated, and the bromo compound further examined.

These experiments seem to point to the fact that if it is desired to increase the illuminating power of coal gas to that of cannel, the benzene series of hydrocarbons must not be exclusively employed. A certain amount of them may be necessary; but to do it in the way ordinarily proposed would be ruinous in cost. Experiment has shown that the extraction of 1 gallon of liquid reduces the illuminating power of the gas about 3 candles; so it is fair to presume that the addition of 1 gallon will increase it by this amount. Every three candles (if carbureted with 50 | 90 benzol—the lowest quality permissible) would, therefore, cost 1s. 8d. per 10,000 cubic feet. But I shall presently show that this is only a mythical figure, as a reaction takes place (not observed before, I believe) which militates against the success of any process of carburation which depends upon the vaporization of a heterogeneous fluid by the passage of a mixed gas through it, already nearly saturated with vapors of varying vapor tension.

In the processes of carburation by the above system, a good "solvent naphtha" has been the usual substance employed. Dr. Letheby's specification for carbureting naphtha stipulated for a quality distilling 70 per cent. at 130° C. and 90 per cent. at 150° C. I have made many experiments with naphtha of this quality, and find that, at a temperature of 20° C., 10,000 cubic feet may be made to absorb and exchange about 3·25 gallons of the light portion, and after a little while scarcely anything is vaporized. With 50 | 90 benzol, at 20° C., 10,000 cubic feet will take up about 7·75 gallons, and at 15° C., about 4 gallons of the lighter portions; while with 90 per cent. benzol, at 20° C., 10,000 cubic feet will absorb and exchange about 15 gallons. Were it not for the ruinous cost of 90 per cent. benzol for such a process, no doubt it might be successfully applied, now that we know more about the principles which govern carburation, and provided a market could be found at a reasonable price for the less volatile portion.

In the experiments just quoted, the apparatus was fed plentifully with the various carbureting agents; but experience soon showed that the quantity taken up became less and less as the benzene evaporated—50 | 90 benzol testing 50 per cent. at 100° C., and 92 per cent. at 120° C., after being evaporated to about one-third tested, the first drop distilled at 103° C., 24 per cent. at 100° C., and 56 per cent. at 120° C. Solvent naphtha, which showed on distillation 35 per cent. at 120° C., 70 per cent. at 130° C., and 90 per cent. at 150° C., yielded after passage of the gas (during which only $\frac{1}{14}$ of the liquid had evaporated) 28 per cent. at 130° C. and 79 per cent. at 150° C. With 90 per cent. benzol, which tested 91 per cent. at 100° C. and a dry flask at 118° C., a residue was left when only one-fourth of the liquid had evaporated, testing 79 per cent. at 100° C. and 92 per cent. at 120° C. I found also that this happens when gasolene is employed as the carbureting agent. A great deal of this information (but without quantities being given) has been recorded by older observers. Hughes in his "Treatise on Gas Works" states: "The main difficulty existing against the carburization of gas is the irregular evaporation of the fluid; a portion of which, when placed in the carbureting vessel, is remarkably volatile, and passes off in abundance, requiring burners with very small holes to prevent the formation of smoke. By degrees, when the most volatile vapors have evaporated (the gas, in consequence, not being enriched), a difficulty arises from the smallness of the burners."

Carrying the above investigation further, I found that the residual spirit from carbureting contained in absolute quantity more toluene, xylene, pseudo-cumene, and mesitylene than entered into the composition of the original fluid. The only way in which I could account for this was by supposing that the gas, in taking up benzene vapor, had deposited the heavier hydrocarbons of less vapor tension to make room for it. This surmise was found to be correct. I passed a large quantity of 17 candle gas through pure benzene (boiling between 80·5° C., and 80·8° C.) until the volume of the carbureting fluid was reduced to one-fifth. The residual spirit now distilled only 80 per cent. at 100° C. and 93 per cent. at 120° C.; proving beyond doubt that toluene, xylene, and the higher hydrocarbons had been deposited from the gas. I carried out the same experiment with gasolene, and found that the aromatic hydrocarbons were also deposited among the residual fluid to quite as great an extent as when using 90 per cent. benzol as the carbureting fluid. Of course, it would be possible to contrive a carbureting apparatus so fed with a continuous stream of the enriching fluid that, while 90 per cent. benzol was entering the apparatus, a constant outflow of toluene or solvent naphtha would take place. I have arranged a small apparatus on this plan; but the results obtained with it have assured me that the process would not be commercially successful. The late Mr. T. Collinge (with whom I have made many experiments), when chemist to the Air Gas Company, of London, found that 1,200 cubic feet of air gas, when made of 16 candle power, contained the vapor of 4 gallons of gasolene, which is as near to the saturation point of a practical temperature as it is possible to work, as, if cooled to 0° C., some of the heavier hydrocarbons were sure to be deposited. I have come to the conclusion, also, that the vapors of the paraffin series of hydrocarbons have, volume for volume or weight for weight, less illuminating power than those of the aromatic series.

The above experiment with air gas seems to point to this; but as the presence of air is found to interfere seriously with the illuminating power of coal gas, it is only fair to assume that it would also injuriously affect the quality of the air gas, of which it constitutes 90 per cent. Mr. W. Lyon, however, has placed on record an experiment which would tend to prove the truth of my supposition. The experiment is given in detail in King's "Treatise on Coal Gas," vol. iii., p. 355. A thousand feet of 17 candle coal gas, by the absorption of 12·7 gallons of gasolene, became 1,270 cubic feet of 38·83 illuminating power; or 2·5 candles produced in 1,000 cubic feet by each gallon of the carbureting fluid. Compare this with the enrichment produced by the use of the benzene series; 1,000 cubic feet of good coal gas will give up 0·3 gallon of liquid hydrocarbons in losing about 9 candles illuminating power, or 3 candles per gallon per 10,000 cubic feet. I must confess I have never (at the ordinary temperature of 15·5° C.) been able to saturate coal gas with as much gasolene as Mr. Lyon succeeded in doing. The utmost quantity I have succeeded in making 1,000 cubic feet of coal gas hold at 15·5° C. has been 2 gallons; so without doubt Mr. Lyon used a more volatile sample than I did, and it contained a less percentage of the heavier hydrocarbons. From these experiments it will be readily seen that carburation in this way, even if it were practically possible, would never pay as a process of enrichment.

I do not think the subject of the mixing of vapors having very great differences of vapor tension has been studied sufficiently in connection with the manufacture of coal gas. If it had, there would have been fewer attempts at carburation in the direction already indicated; and other phenomena, seemingly inexplicable, would have been readily explained. In King's "Treatise on Coal Gas" (*loc. cit.*) it is stated: "At Lowell, Massachusetts, the naphtha gas, after being measured, was passed into the hydraulic main of the coal gas, with which it was washed and purified. The object of mixing the gases at this point is not clear, except with the idea of effecting a thorough amalgamation of the compound in the course of its subsequent treatment." There is no doubt that by this method the illuminating power of the gas would be more permanent in consequence of time and opportunity being given for the vapors of high tension to dislodge and occupy the place of those of low tension, and thus be able to withstand greater variations of temperature without the tendency to precipitate any illuminant in the liquid form.

It was not my intention at the outset to speak of any method of enrichment by means of solid hydrocarbons; but perhaps the method of carburation known as the albo-carbon light deserves to be noticed. Upon ordinary gaslights it may, perhaps, be difficult to assure a casual observer of the efficiency and economy of this principle; but with 9 candle gas there is no difficulty whatever. Most of you will be aware that at the Rockingham Gas Works, where my process for the extraction of benzene from the gas is in operation, the residual gas is quite unfit for illumination. After extracting about 4 gallons of liquid hydrocarbons per 10,000 cubic feet of the gas, this debenzolized gas has to be burnt from one of Bray's "market" burners in order to illuminate a room 10 feet square, and that not very satisfactorily. By employing the albo-carbon light, the illuminating power is with ease brought up to 20 candles, and the gas consumption reduced from 23 to about 3½ cubic feet per hour. I think the albo-carbon system deserving of great extension, though I am doubtful whether the average householder is sufficiently regardful of his purse to undergo the extra labor of charging the apparatus periodically with the naphthalene.

I must now return to the subject mentioned in the early part of this paper, viz., the conversion of the tar into gas, and a method of using this gas for enriching the principal portion; as, if it could be effected satisfactorily, I believe it would bring a greater revenue to the gas companies than by selling the tar at such ridiculously low prices as some of them are at present obtaining. Tar is slowly but assuredly increasing in

quantity, though means might be adopted in the gas works whereby a large percentage might be curtailed. Low temperatures, with 9,000 cubic feet of gas per ton, will yield with some coals 16 gallons of tar; while high temperatures will yield but 9 gallons, with about 11,000 cubic feet of gas. Now, if in every gas works they would in this way curtail the supply of tar, they would be reducing the production of the United Kingdom by about 30 per cent., which would not fail to have an effect on prices, both of benzol and of pitch, which are now extremely low, and will not rise unless the supply of tar is diminished. Then, again, instead of selling tar, it can be made to replace the cannel coal now almost universally employed for increasing the illuminating power of ordinary gas. I have already attempted to show that the gaseous illuminants of gas made from cannel coal are quite different to those existing in coal gas; and coal tar can, by proper treatment, be made as valuable to the gas maker as the best cannel coal.

In the early days of gas making, the attempts to gasify tar were of a very crude nature. It was run into retorts, there to be reheated, or on to trays placed inside them, with the result that every pipe and outlet became speedily choked with pitch. The nature of tar is now more completely understood, and some of us may be able to avoid the mistakes into which early operators fell. There are in tar three substances of no use to the manufacturer of gas intended for illuminating purposes, viz., pitch, naphthalene, and anthracene; and unless these are extracted before treatment, they become his *bête noire*. The process I am now about to advocate depends upon the elimination of these three products from the tar, and the conversion of the remainder into gas. The boiling point of anthracene is so high that the heat of the retorts has very little action upon it, unless the heat is raised too high, in which case viscid oils are produced, which tend to choke up the apparatus. Naphthalene is exceedingly difficult to deal with. It volatilizes in a great measure, and chokes up the condenser and other cool portions of the apparatus; while another portion is changed into dinaphthyl and iso-dinaphthyl, which are of no use to the gas maker. Pitch, when carbonized, yields only about 25 per cent. of volatile matter, nearly entirely gas of no light-giving value whatever; and, of course, if this gas were mixed with that from the coal, it would much dilute its illuminating power.

It is well known that light oils from gas tar, petroleum spirit, petroleum residues, creosote, heavy oils from gas tar, etc., become gasified to a great extent by heating to redness, or by passing over red-hot surfaces, and about 80 cubic feet of 50 candle gas thereby obtained per gallon, possessing a specific gravity of 0·912, which, with oils weighing 10·8 lb. to the gallon, is equal to 16,600 cubic feet of 50 candle gas per ton. Now, this rich gas approaches more nearly the composition of rich cannel gas than that made from any other substance. The greatest illumination is produced from the formation of very low boiling hydrocarbons of great vapor tension, such as crotonylene (C_4H_6), which I have often separated in large quantities; and to these the illuminating power is principally due. Thorpe and Young (*Ann. Chem. Pharm.*, clxv., 1) found that solid paraffin, by heating under pressure, is resolved into a mixture of liquid products consisting essentially of low boiling paraffins and medium and high boiling paraffins and olefines; and there is but little doubt that some reaction or decomposition of this nature takes place when the vapors of the coal tar oils are passed through a red hot retort.

In order to carry out this process of enrichment upon a practical scale (say for works carbonizing 50 tons of coal per day), a set of three 10-ton tar stills would have to be provided, so that they might be worked in sequence, one always being run off and refilled. The raw tar is distilled in the usual manner, and the distillate conveyed into three separate tanks, A, B, and C; the still being stopped when a sample of the pitch, on being withdrawn, twists easily at a temperature of 55° C., and when thus made it is of an extremely good quality, and commands a ready sale. The contents of tank A will remain liquid, naphthalene will separate from tank B on cooling, and anthracene from tank C. If tank B is constructed in the form of a filter, the naphthalene can be easily removed from the process, and either worked up, sold, or used as fuel. The oils in tank C must be filter-pressed, to remove the anthracene; after which the contents of all are ready to be made into gas. When sufficient oils have accumulated, another of the stills is filled with a mixture from the tanks A and B, and the whole slowly distilled; the vapors being passed directly into one end of a *through* retort heated to dull redness, the gasified hydrocarbons passing out at the other end by means of the ascension pipe, and mixing with the gas from the ordinary retorts. When four-fifths of the contents of the still have been vaporized, the fire is withdrawn and the still filled up with raw tar, which is distilled as before, and the pitch run out for sale; after which the still is again ready for vaporizing another batch of oils. When sufficient filtrate from the anthracene has accumulated, it is distilled in whichever still happens to be at liberty. The first fourth is run to the creosote or B tank, the second fourth into the anthracene or C tank; the still being stopped when the pitch will just soften at 50° C., when it is run off into the pitch house in the same manner as when dealing with ordinary tar. The whole process is so simple that any intelligent lad might work it. It does not depend upon any complicated chemical tests; a thermometer and a hydrometer being the only apparatus required. In order to prevent misunderstanding, I may add that the process is patented, and I hope soon to see it at work. In this way every gas works would be able to supply an illuminating gas of good quality without the aid of cannel coal, to be producers also of pitch and anthracene of the very best qualities, with which no one could ever think of competing.

In conclusion, let us see how this would affect the illuminating power of the gas made by this process. In the case of coal and cannel:

100 tons of ordinary coal give 10 M feet of 17-candle gas.
5 " cannel coal " 12 M " 28 " "
Produce:

Coal........	1000 M	at 17 candles......	17,000
Cannel......	60 M	at 28 "	1,680
In all....	1060 M	....	at 17·6 candles.

Taking coal and gas tar:
100 tons of ordinary coal give 10·0 M ft. of 17-candle gas.
2·8 " tar oils " 16·6 M " 50 " "
Produce:

Coal........	1000·0 M	at 17 candles.....	17,000
Tar oils.....	46·5 M	at 50 "	2,325
In all....	1046·5 M	....	at 18·4 candles.

In these calculations, I have taken 12 gallons of tar to be the produce from a ton of coal. If more tar is produced than this, the comparison will, of course, be more favorable. I have not gone to the length of calculating out the results according to the price of cannel, which must vary in every locality according to the cost of carriage; but I have endeavored to show that the 7 tons of tar produced from 100 tons of coal is of value to the gas maker equal to nearly 10 tons of cannel coal. It therefore seems to me to be the height of absurdity to let the tar go away from the gas works at some of the very low prices at present ruling; and, moreover, I have not reckoned in the values of the pitch and anthracene which would also be produced. One through retort will give about 500 cubic feet of gas per hour, besides a certain quantity of tar and ammoniacal liquor. This is equal to the decomposition of some 7 gallons of oil per hour.

THE BALM OF GILEAD.

(POPULUS CANDICANS.)

Where this poplar grows naturally in the Eastern United States it makes a handsome tree from 60 feet to 70 feet in height in the most favorable spots, such as

MALE AND FEMALE CATKINS OF POPULUS CANDICANS.

LEAVES OF POPULUS CANDICANS.

THE BALM OF GILEAD TREE (POPULUS CANDICANS).

the margins of rivers, and even where the soil is poor and dry it grows over 50 feet in height. It is, like all the poplars, a rapid grower, and being indifferent as to soil, it frequently thrives when other trees fail. It has long been a favorite tree in this country, having been introduced over a hundred years ago. It was named by Aiton, who includes it in his "Hortus Kewensis." He gave the name candicans presumably because of the hoary look the tree has when the whitish under-surfaces of the leaves are upturned by the wind. This poplar is nearly related to the common balsam poplar or tacamahac (P. balsamifera), of which, indeed, it may be only a variety botanically. From a planter's point of view it is, however, abundantly distinct, and may be at a glance distinguished by its very broad leaves, which are heart shaped at the base, deep green above and whitish beneath. The habit of growth is somewhat pyramidal, and cannot be called handsome until the tree has reached a large size, when the irregular branches and spreading head render it picturesque. A number of young and old trees planted together make a handsome group, for then the broad masses of light on the large foliage has a striking effect. The bark of the trunk has that same peculiar grayish hue which renders the common abele (P. alba) so picturesque. It is an invaluable tree for planting in places where any buildings or unsightly objects require to be screened, and it is even better for this purpose than the smaller leaved poplars. It is also a capital tree to plant as a nurse for choicer kinds, the only drawback being that, when they are cut down, the suckers which spring from the old stool are apt to be troublesome, for they are not easily eradicated. It grows most rapidly in moist, rich soils, and no better trees could be planted by the margins of lakes or on islets. It is a most desirable tree to plant near houses, on account of the balsamic fragrance of the resinous buds, which perfume the air in spring, as does also the balsam poplar; the tassels of red stamens, too, have a pretty effect in April, just before the leaf buds burst. Another beautiful phase of this poplar is the peculiar delicate yellowish hue of the new foliage, and which, in harmony with the tender greens of other trees, has a charming effect. Like the balsam poplar, it is apt to be injured by the wind if planted in very exposed positions, on account of its heavy and somewhat brittle branches.

This tree is commonly called in nurseries the Ontario poplar (P. ontariensis), and there is a form of it with variegated leaves, which, however, is not remarkable for beauty or distinctness.—*The Garden.*

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